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US Army Corps
of Engineers

A STUDY OF GEOLOGIC AND HYDRAULIC PROCESSES AT EAST PASS, DESTIN, FLORIDA

Volume I
Main Text and Appendices A and B

by

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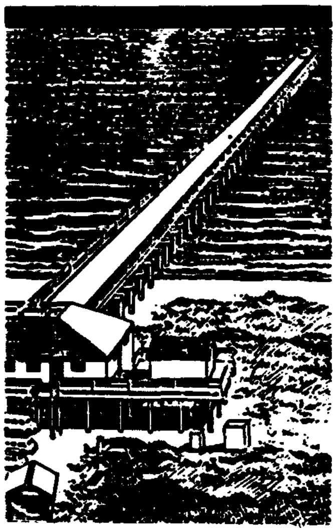

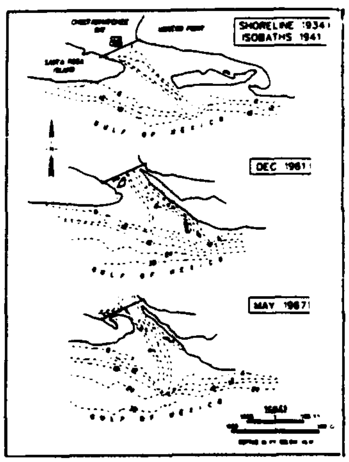

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From 1983 to 1991, the Coastal Engineering Research Center and US Army Engineer District, Mobile, monitored waves, currents, tidal elevations, bathymetry, and shoreline changes at East Pass Inlet, Destin, FL. Based on these data and on historical records, a three-phase model has been developed that describes the inlet's behavior during the last 120 years:

a. *Phase 1* (pre-1928), spit development and breaching, covering the period when the inlet was oriented northwest-southeast between Choctawhatchee Bay and the Gulf of Mexico.
b. *Phase 2* (1928-1968), stable throat position but main ebb channel that migrated over a developing ebb-tidal shoal. This phase covers the time after the inlet breached Santa Rosa Island in a north-south direction and then migrated eastward.
c. *Phase 3* (1968-present), after rubble-mound jetties were built, the throat and main ebb channel were stabilized, while ebb-tidal shoal grew.

Despite the jetties, East Pass has continued to try to move eastward. The driving forces of the eastward migration are hypothesized to be (a) wave forces--the predominant wave direction measured in

(Continued)

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10-m water depth is from the southwest, while the shore trends east-west; (b) backbay tidal channel and flood-tidal shoal geometry direct ebb currents towards the eastern shore of the inlet; (c) because of freshwater inputs, the ebb flow is longer in duration and higher in velocity than the flood. Maximum measured ebb currents in the inlet are over 5.0 ft/sec (1.5 m/sec), producing a discharge of about 90,000 cu ft/sec (2,500 cu m/sec).

Maintaining the inlet in its present location is expected to be increasingly difficult as erosion along the east shore, driven by the inlet's inexorable eastward migration, continues. Major engineering work may be needed to prevent the inlet from bypassing the landward end of the east jetty.

To maintain a 12- by 180-ft navigation channel, the dredging rate between 1951 and 1991 has been 97,000 cubic yards/year (74,000 cubic metres/year). The construction of the jetties did not reduce this rate. A minor reduction may be possible by relocating sections of the channel within the inlet. Significant dredging reduction may be possible only by reducing project depth.

Contents

Preface xi

1—History of East Pass Project 1

General History Including Federal Projects at East Pass, 1827-1969 1
History of Jetties and Present Project, 1969-1990 10
Monitoring Project at East Pass 15

2—Geography and Geology of East Pass 17

General 17
Choctawhatchee Bay 17
Santa Rosa Island 19
Moreno Point (Destin) 19
Physical Oceanography 20
Longshore Drift 23

3—Geologic Model of Inlet Behavior 25

Phase 1: pre-1871 to 1928 25
Phase 2: 1928 to 1968 26
Phase 3: 1968 to Present; Possible Future Behavior 29
Proposed Driving Forces of Eastward Migration 31

4—Field Data Collection and Results 33

Wave Data 1987-1990 33
Ebb-Tidal Shoal 1967-1990 39
Tidal Hydraulic Data 47
Sediment Grain Size 67
Shoreline Changes 1965-1990 71

5—Dredging in East Pass, 1931-Present 75

Historic Dredging Data 75
Analysis of Channel Shoaling 77

6—Summary and Recommendations 81

General 81
Geological Effects of the Jetties 82
Weir 83
Dredging Recommendations 84
Engineering Summary 86

References 89

Appendix A: Chronological Listing of Cultural and Natural Events A1

Appendix B: Estimation of Error of Ebb-Tide Shoal Growth Calculations B1

Appendix C:[1] Directional Wave Data, 1987-1990, East Pass, Florida C1

Appendix D: Plots of Wave Data, 1987-1990, East Pass, Florida D1

Appendix E: Plots of Water Depth and Mean Currents, 1987-1989, East Pass, Florida E1

Appendix F: Tide Curves, Choctawhatchee Bay and Destin, Florida, September-November 1983 . . . . F1

Appendix G: Tide Curves, Choctawhatchee Bay and Destin, Florida, March-June 1984 . . . . G1

Appendix H: Tide Curves, Gulf of Mexico, Choctawhatchee Bay and Destin, Florida, March-May 1987 . . . . H1

Appendix I: Current Velocity and Direction Curves, East Pass Main Channel, Flood Tide Shoal, and Old Pass Lagoon, October 1983 . . . . I1

Appendix J: Current Velocity and Direction Curves, East Pass Main Channel, Flood Tide Shoal, Old Pass Lagoon, and Santa Rosa Sound (Fort Walton Beach), May 1984 . . . . J1

Appendix K: Current Velocity and Direction Curves, East Pass Main Channel, April 1987 . . . . K1

[1] A limited number of copies of Appendixes C-K (Volume II) were published under separate cover. Copies are available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Figures

Figure 1.	Vicinity map, East Pass, Destin, FL	2
Figure 2.	East Pass and Choctawhatchee Bay detail	3
Figure 3.	Aerial photograph of the East Pass area, 28 June 1987 .	11
Figure 4.	Northeast Gulf of Mexico, 25 February 1990	21
Figure 5.	Pre-1871-1928 East Pass inlet	25
Figure 6.	1934 - 1967 East Pass	27
Figure 7.	February 1965 aerial photograph of East Pass taken from Gulf of Mexico looking north.	30
Figure 8.	Summary of wave data from June 1989	35
Figure 9.	Percent occurrence histogram of all waves measured by CERC directional wave gage, 4 miles west of East Pass between 1987 and 1990	36
Figure 10.	Percent occurrence histogram for waves higher than 0.7 m measured by CERC gage, 4 miles west of East Pass	37
Figure 11.	Percent occurrence histogram for waves higher than 1.0 m measured by CERC gage, 4 miles west of East Pass	38
Figure 12.	Area used for analysis of ebb-tidal shoal	40
Figure 13.	East Pass ebb-tidal shoal, June 1967	41
Figure 14.	East Pass ebb-tidal shoal, February 1990	42

Figure 15. Isopach map showing amounts in feet of erosion and deposition at East Pass ebb-tidal shoal 44

Figure 16. Ebb-tidal shoal growth from 1967 through 1990 45

Figure 17. Maximum near-surface (2 to 4 ft below surface) currents measured 25-26 October 1983 in East Pass at sta 1-4 50

Figure 18. Near-surface current directions and velocities measured 25-26 October 1983 in East Pass at sta 1-4 51

Figure 19. Currents measured at 02:10 CST on 26 October 1983 in East Pass at sta 1-4 53

Figure 20. Currents measured in the mouth of Old Pass Lagoon 25-26 October 1983 54

Figure 21. Discharge hydrograph based on data collected 25-26 October 1983 in East Pass and Choctawhatchee Bay 56

Figure 22. Tide curves from Choctawhatchee Bay and Old Pass Lagoon 57

Figure 23. Near-surface current directions and velocities measured 15-16 May 1984 in East Pass at sta 1-4 58

Figure 24. Near-surface, middepth, and bottom currents measured 15-16 May 1984 in East Pass at sta 3 59

Figure 25. Discharge hydrograph based on data collected 15-16 May 1984 in East Pass and Choctawhatchee Bay 60

Figure 26. Comparison of water flow over weir in west jetty with flow through main East Pass Channel at sta 1-4, 15-16 May 1984 62

Figure 27. Discharge hydrograph based on data collected 15-16 April 1987 in East Pass and Choctawhatchee Bay 63

Figure 28. Tidal elevations measured in the Gulf of Mexico and in Choctawhatchee Bay 64

Figure 29. Discharge hydrograph based on data collected 20-21 April 1938 in East Pass and Choctawhatchee Bay 66

Figure 30.	Sediment grain-size analyses, East Pass ebb-tide shoal .	68
Figure 31.	Sediment grain-size analyses, East Pass Channel	69
Figure 32.	Sediment grain-size analyses, East Pass flood-tide shoal	70
Figure 33.	Shoreline changes, 1965-1990	72
Figure 34.	Cumulative dredging volumes, 1931-1991, East Pass and Old Pass Channels and Deposition Basin	76
Figure 35.	Profiles across East Pass Inlet, Line 32+00, 1987 . . .	78
Figure 36.	Profiles across East Pass inlet, Line 44+00, 1987	79
Figure 37.	Location of present navigation channel and location of thalweg	85

Tables

Table 1. East Pass, Florida, Dredging Volumes 6

Table 2. Longshore Drift Estimates, East Pass, Florida 23

Table 3. Ebb-Tidal Shoal Volumes 46

Table 4. Tidal Current Measurements, East Pass, Florida 48

Table 5. Water Elevation Measurements, Choctawhatchee Bay, Florida 49

Table 6. Maximum Currents in Feet per Second Measured at East Pass in 1983, 1984, and 1987 65

Table B1. Error Estimates of Ebb-Tide Shoal Depth Differences B2

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square metres
cubic feet	0.02832	cubic metres
cubic yards	0.7646	cubic metres
feet	0.3048	metres
feet per second	0.3048	metres per second
inches	2.540	centimetres
miles (US statute)	1.609	kilometres
square miles	2.590	square kilometres
miles (US nautical)	1.852	kilometres
tons (2,000 pounds, mass)	907.1847	kilograms

Preface

The study reported herein was conducted by the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES), as part of the Monitoring Completed Coastal Projects (MCCP) Program at East Pass, Destin, FL. The MCCP Program Manager is Ms. Carolyn M. Holmes. This program is sponsored by Headquarters, US Army Corps of Engineers (HQUSACE). The HQUSACE Technical Monitors are Messrs. John H. Lockhart, Jr.; James E. Crews; John G. Housley; and Robert H. Campbell.

This report was written by Mr. Andrew Morang, Prototype Measurement and Analysis Branch (PMAB), Engineering Development Division (EDD), CERC, under the direction of Mr. William L. Preslan, Chief, PMAB, and Mr. Thomas W. Richardson, Chief, EDD. Mr. Charles C. Calhoun, Jr., was Assistant Director, CERC, and Dr. James R. Houston was Director, CERC, during the report preparation.

Numerous people have helped collect the field data. Technicians from CERC, directed by Mr. William Kucharski, installed and maintained the wave gages. Surveying and current measurements were directed by Mr. Geary McDonald, US Army Engineer District, Mobile (CESAM). Hydrographic surveys were supervised by Messrs. Alton Colvin and Roger Bush, Panama City Area Office, CESAM. Mr. Rex Yocum, contract student, CERC, digitized bathymetric and tide charts.

The author also wishes to thank the following people, who have generously contributed their time and effort to the completion of this project: Drs. Nicholas C. Kraus, Senior Scientist, CERC; Dag Nummedal and Oscar Huh, Department of Geology and Geophysics, Louisiana State University, Baton Rouge, LA; Gregory Stone, Department of Geography and Anthropology, Louisiana State University, Baton Rouge, LA; Jon Boothroyd, Geology Department, University of Rhode Island, Kingston, RI; Messrs. Benton Wayne Odom, Pete Robinson, and Paul Bradley, CESAM; Mr. Alton W. Colvin, District Engineer, Panama City Area Office, CESAM; and Mr. James E. Clausner, EDD, CERC.

Messrs. David D. McGehee, PMAB, and Richard Champion, formerly of CESAM, prepared the 1986 plan for the East Pass monitoring program.

Mr. Francis F. Escoffier, CESAM, retired, who helped conduct the 1938 field studies at East Pass, shared with the author insights and experience gleaned during his 50 years of study of Florida coastal processes.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Leonard G. Hassell, EN.

1 History of East Pass Project

General History Including Federal Projects at East Pass, 1827-1969[1]

General history before 1928

The East Pass Inlet from the Gulf of Mexico into Choctawhatchee Bay is located in Okaloosa County, Florida (Figure 1).[1] Being the only inlet along this stretch of the Florida Panhandle, it had been used by vessels since before 1827, when John L. Williams described it in his book, *A View of West Florida Embracing Its Geography, Topography:*

> The Choctawhatchee Bay is at least forty miles[2] long, and from seven to fifteen wide. It receives the Choctawhatchee River through many mouths, at the east end; while on the north side there enters Cedar Creek, the Alaqua River, Rock Creek, Boggy Creek and Twin Creek. This bay is much affected by storms; and many shoals running far into it, the navigation is considered somewhat dangerous. It has two outlets. The pass L'Este communicates with the sea, seven miles south-east from the west end of the bay, at the west end by St. Rosa Sound. When a heavy swell of the sea meets the ebb tide on the pass L'Este the breakers render it impassable. The British established a very profitable fishery here. It might still be improved to great advantage.

During the early 1800's, pirates, including Lafitte, reportedly beached their boats near Mary Esther to effect repairs and marry the local Choctaw women

[1] For the convenience of the reader, a chronological summary of events, dredging, and construction pertaining to East Pass is provided in Appendix A of this report.

[2] A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page ix.

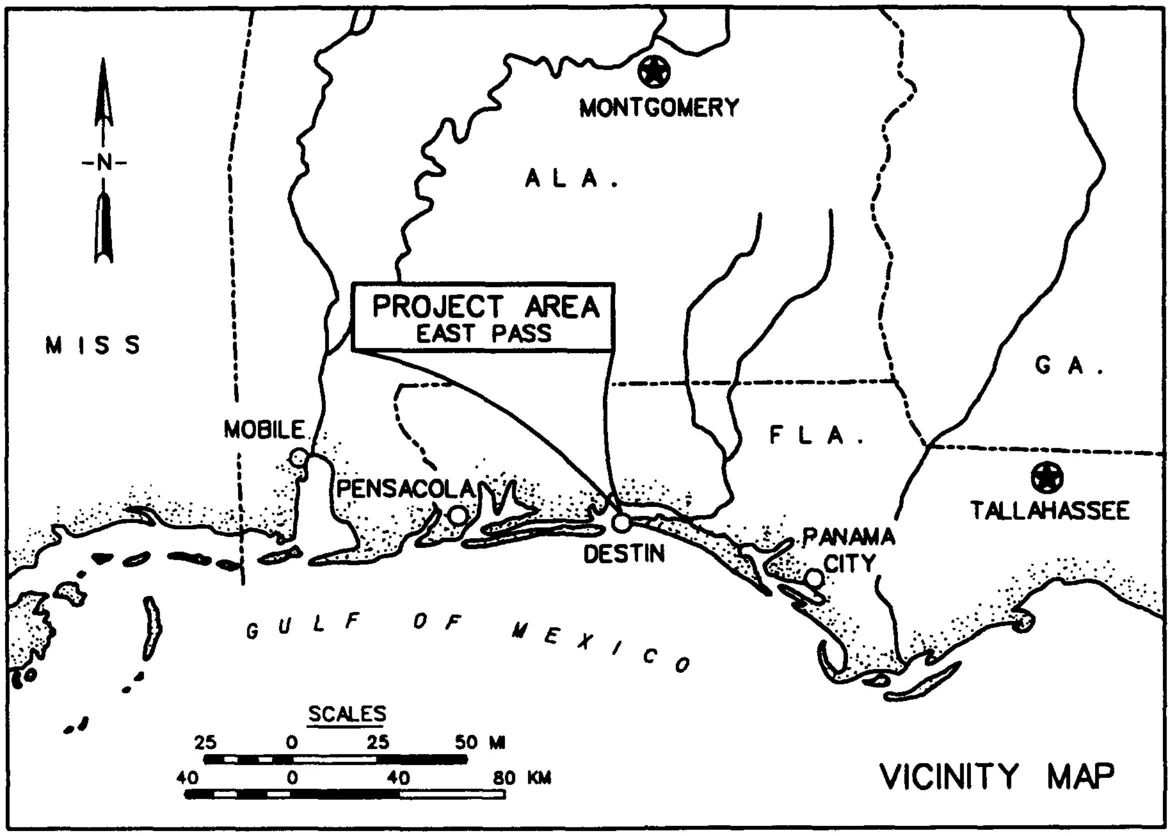

Figure 1. Vicinity map, East Pass, Destin, FL

(Figure 2). Corroded doubloons and French ecus have been occasionally found on Santa Rosa Island, causing speculation that a pirate ship crammed with gold had been wrecked there. In the 1820's, several families settled along the Choctawhatchee near Freeport. The primary water route between Choctawhatchee Bay and Pensacola was along Santa Rosa Sound, although some vessels may have used the gulf route. In 1845, on the Monroe Point military reservation at East Pass, a New London fishing master, Captain Destin, founded the town of Destin for red-snapper fishing (Angell 1944). During the Civil War, no major military actions occurred in the area, but a Union frigate anchored off East Pass to blockade the bay. The frigate and Camp Walton's supply ship occasionally shelled each other across Santa Rosa Island (Massoni 1988). There is no known hydrographic map of East Pass before 1871; at that date the inlet had a northwest-southeast orientation, running south of Moreno Point along what is now called Old Pass Lagoon and exiting into the Gulf of Mexico about 1.5 miles to the east of its present mouth. Between the mid-1800's and the 1910's, major sawmills and turpentine camps were built in the forests north of Choctawhatchee Bay. The timber and other products were exported to South America via the port of Pensacola. Nevertheless, general commercial development around Choctawhatchee Bay remained hampered because of the limited rail lines and the poor roads. Supplies for the residents of Fort Walton, Destin, and the Choctawhatchee National Forest settlements were delivered by steamboat from Pensacola.

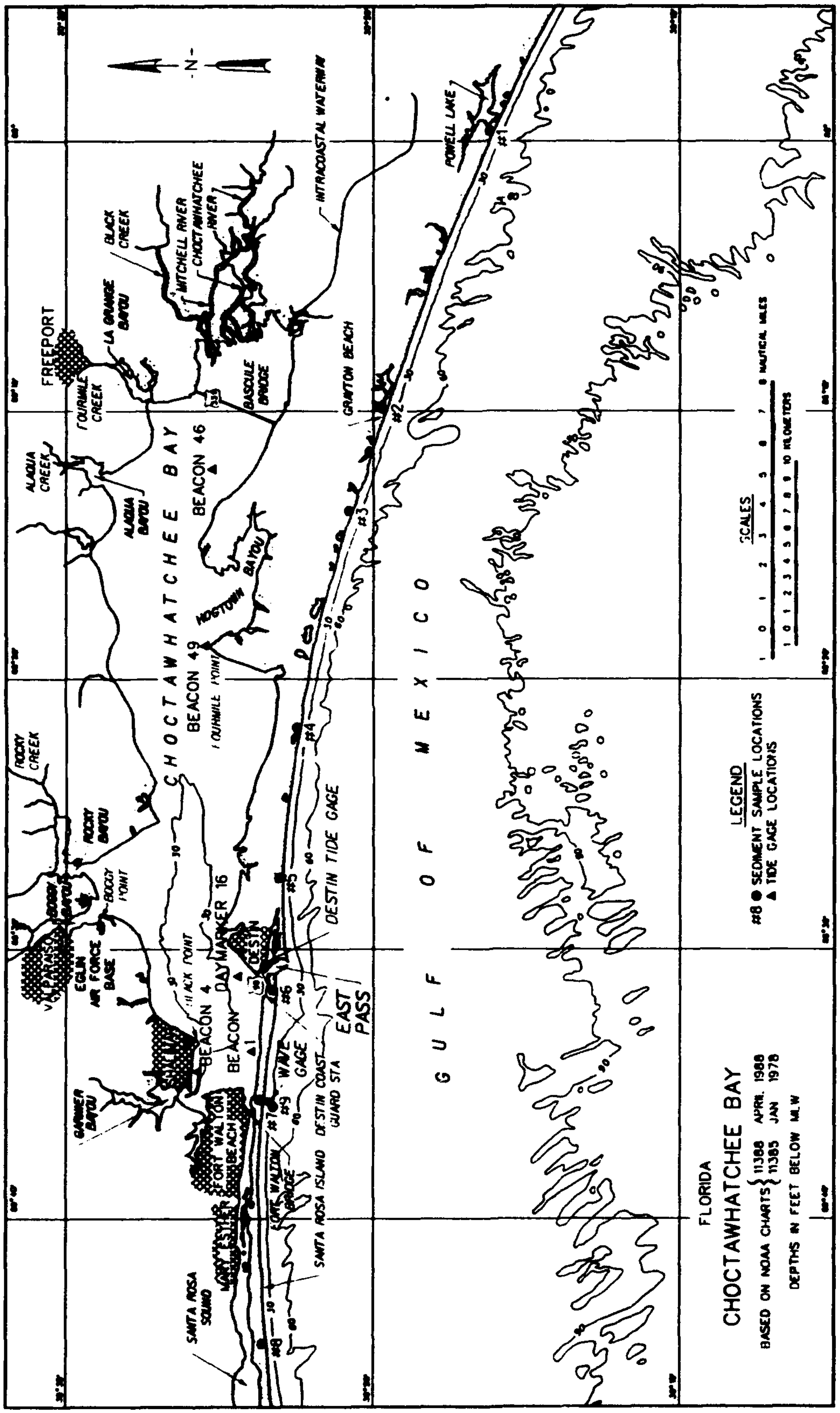

Figure 2. East Pass and Choctawhatchee Bay detail

Commercial development and population in the Choctawhatchee Bay region increased after the 1910's. Refugees from the Mexican Civil War settled in Fort Walton. A dye factory, owned by a German company, operated along the shores of Black Bayou. During World War I, the factory is said to have made explosives and provided supplies to German U-boats off the coast until the Germans fled and destroyed their machinery (Angell 1944). During the Florida boom of the early 1900's, promoters and investors dreamed of making the area the "Riviera of America" and advertised beautiful white, sandy beaches, the warm climate, and the cool breezes. They neglected to mention that there were few roads and no electricity, and that yellow fever and typhus took an annual toll; nevertheless, a few small resort hotels opened. Ambitious Chicago developers, with dreams of merchant fleets riding in Choctawhatchee Bay, chartered the Port Dixie Harbor and Terminal Company to build wharves for ocean liners, a rail line north, and a beautiful 1-square mile city with 100-ft-wide boulevards. Their plans called for a major navigation channel through East Pass, and on 4 January 1924, a proposal was submitted to Congress for channels 12, 18, and 20 ft deep (cited in US Congress 1950). US Army engineers anticipated the exorbitant cost of maintaining a 20-ft channel, and rival commercial interests from Pensacola and Panama City suppressed the project (Angell 1944). The dreams for Port Dixie, Valparaiso, and the Choctawhatchee Bay area as the Riviera of America finally died with the onset of the Great Depression.

A much more modest proposal for a channel 6 ft deep was made in 1928 after a preliminary survey concluded that this channel would be maintained naturally except after severe storms (US Congress 1928). Annual maintenance costs were estimated to be $600. During the mid-1920's, the Gulf Coast Highway (now US Highway 98) was being built, and communications were improving. In 1926, Destin had 32 residents, and the total population of the Choctawhatchee Bay area was 2,200 (US Congress 1928). Some 15 to 20 fishing boats used East Pass daily. Local fishermen stated that they could not take advantage of the rich nearby fishing banks unless a deeper water channel were provided, and they emphasized the necessity of channel depth much deeper than the draft of vessels because of the rough water encountered at the entrance to the inlet.

In April 1928, a severe storm and high tide partially breached Santa Rosa Island near the present location of inlet. On 12-15 March 1929, the most intense rainfall of record occurred in the area, with 16 in. of rain falling in 48 hr. This rainfall caused record floods on the Choctawhatchee River, and the water level in Choctawhatchee Bay rose 5 ft. Local inhabitants dug a pilot channel along the route of the 1928 breach to help augment the runoff of the bay. Once the pilot channel was cut, the water from the bay "rushed out like a mill-race" (Angell 1944). The channel rapidly widened and eventually became the main East Pass Inlet (US Congress 1950, Goldsmith 1966).

Navigation projects

Navigation through the new East Pass continued to be hazardous for small boats. The bar at the edge of the ebb-tidal shoal had a tendency to shift and shoal during storms. Frequently, Destin fishing boats were forced to make the long detour via Pensacola and Santa Rosa Sound in order to safely return home. To enhance safety and improve navigation, the first Federal project at East Pass was adopted by the 70th Congress on 3 July 1930, and provided for a channel not less than 6 ft deep and 100 ft wide from Choctawhatchee Bay to the Gulf of Mexico (US Army Engineer Office, Mobile 1939). The first dredging at the project was in April 1931, when 20,000 cu yd of sand was removed from the Old Pass Channel at a cost of $8,600. Table 1 lists all the Federally sponsored dredging in the East Pass and Old Pass channels from 1930 to 1991. Data on locally supported dredging are not included.

The fixed-span highway bridge over East Pass was completed in 1933. This bridge has served as a convenient reference marker in aerial photographs of the inlet. Although communications had improved, throughout the 1930's Destin remained quiet. Several floods and hurricanes are on record (see Appendix A), and the inlet was dredged at infrequent intervals. In April 1938, a 9- by 100-ft canal was completed from Choctawhatchee Bay to St. Andrews Bay, finally allowing vessels to travel from Panama City to Pensacola without having to transit the open Gulf of Mexico.

One of the most important developments in the region was the establishment on 14 June 1935 of the Valparaiso Bombing and Gunnery Range at the Valparaiso Airport. The relatively uninhabited expanse of the Choctawhatchee National Forest, adjacent to Choctawhatchee Bay and the Gulf of Mexico, made the area a natural choice for the bombing range. Promoted by the urgency of the war in Europe, negotiations for the acquisition of the forest by the military proceeded from 1937 to 1940. On 27 June 1940, an Act of Congress (Public Law (PL) 668, 76th Congress) transferred the Choctawhatchee National Forest from the Department of Agriculture to the War Department (Angell 1944). The Eglin Field Military Reservation was established on 1 October 1940. During World War II, there was a tremendous growth of research, testing, and training at Eglin. Many tests were conducted over the Gulf of Mexico, and supporting patrol craft had to transit through East Pass or be stationed in Panama City or Pensacola. In June 1945, the Army Air Force paid the Corps of Engineers to dredge a channel 12 ft deep and 180 ft wide to accommodate the Eglin patrol boats.

Because of increasing commercial and military traffic in the late 1940's, a proposal for a 12- by 180-ft channel was submitted to the 81st Congress in February 1950 (US Congress 1950). The proposal included the following endorsement from the Executive Office of the President, Bureau of the Budget:

> The report states that practically all the benefits that would result by provision of the improvement would accrue to a

Table 1
East Pass, Florida, Dredging Volumes (cubic yards)[1]

Date	East Pass Channel	Old Pass Channel	Other, Including Deposition Basin
Apr 31		20,000	
Aug 37		39,100	
Dec 37	22,300		
Mar 42	43,700[2]		
Oct 44	46,100[2]		
Mar 47	19,300[2]		
Nov 47	59,200[2]		
Jan 50	41,800[2]		
Sep 50		25,500	
Sep 51		16,200	
Feb-Apr 52	139,200		
Jan 53	38,700		
Apr 54	67,700		
Dec 54		11,700	
May 55		10,800	
Aug-Sep 55	56,300	22,700	
May 56		22,000	
Nov 56	75,900	51,700	
Aug 57			
Feb 58	43,600	52,800	
Mar 58			
Feb 59	81,700	28,900	
Mar-May 60	45,800	63,100	
May-Jun 61	80,600		
Jul-Oct 62	123,800		
Mar-Apr 63	67,800	18,600	
Feb-Mar 64	170,400[3]		
Apr-May 65	86,500		
Apr 66	136,000		

(Continued)

[1] See Notes and Definitions at end of table.
[2] May include Old Pass 6- by 100-ft channel.
[3] Both East Pass main channel and Old Pass Lagoon Channel.

(Sheet 1 of 3)

Table 1 (Continued)

Date	East Pass Channel	Old Pass Channel	Other, Including Deposition Basin
Mar 67	42,100	6,400	
Dec 67	24,600		
Sep-Dec 68	28,200[1]		360,000
Jan 69	10,200	15,100	57,100
July 69 and Apr 70	80,700		
Feb 70			118,500
Aug 70		26,700	
Jan 71	81,000	58,000	
Jan-Mar 72	76,000	57,400	287,000
Feb 73		42,500	
Mar 73		38,400	
Oct-Nov 73		23,400	
Dec 73		9,800	
Jan 74	21,000	84,000	
Jan 75	120,000		
Sep 75	14,600	17,800	
Apr-May 76	94,000	62,300	
Apr-May 77	44,000	15,100	
May-Jun 78	72,700		
Mar-May 80		22,600	
Aug-Sep 80	67,000	2,100	
Feb 81		20,900	
Jul 81	44,200		
1982	30,500	45,700	
1983	59,900		
1984	141,400	37,900	
1986	150,400	32,000	
1987	126,000		
1988	210,800	21,300	
Mar 91	131,971	11,500	

(Continued)

[1] Both East Pass main channel and Old Pass Lagoon Channel.

(Sheet 2 of 3)

Table 1 (Concluded)

Notes and Definitions:

Sources of dredging data

1930-1970: Report of the Chief of Engineers, US Army (printed annually)

1970-1981: Disposition Form dated 23 October 1981, by Mr. Alton Colvin, Area Engineer, Panama City Area Office (Mobile District Archives). Quantities and costs listed by Mr. Colvin tend to be higher than those in the Annual Reports.

1981-1989: Tabulation by Mr. Paul Bradley, Mobile District. These quantities are different from those in the Annual Reports, but have been used because they were compiled directly from engineering records in Mobile District's operations files.

East Pass Channel

Nomenclature: In the Annual Reports of the Chief of Engineers, US Army, the main channel from the Gulf of Mexico to Choctawhatchee Bay is called several names, including Bay Channel, Gulf Entrance Channel, Entrance Channel, Bar Channel, and East Pass Channel.

1930-1951: Channel 6 ft deep by 100 ft wide from Gulf of Mexico to Choctawhatchee Bay. Some of the dredging volumes may include the side channel which leads into Old Pass Lagoon.

1951-present: Channel 12 ft deep by 180 ft wide from Gulf of Mexico to Choctawhatchee Bay, approx 3 miles long. Includes the dredged channel across the ebb-tidal shoal, through the inlet, under the Hwy 98 bridge, and along the north (i.e. east) channel that follows the east side of the flood-tide shoal in Choctawhatchee Bay.

General: The records do not detail from where material has been dredged. Based on aerial photographs and hydrographic charts, the author concludes that about half of the dredging volume typically came from the ebb-tide shoal, while most of the rest came from the inlet between the Hwy 98 bridge and the jetties. The channel north of the bridge appears to have been relatively stable, not needing much dredging. The west channel, south of the flood-tide shoal, has been dredged from the Hwy 98 bridge to the US Coast Guard Station (USCG); this is a separate project for which Mobile District has not been responsible or involved. The listed dredging volumes do <u>not</u> include this west channel.

Old Pass Channel

Nomenclature: In the Annual Reports, the channel leading from the East Pass Channel into the Old Pass Lagoon (Destin Harbor) is called the Destin Harbor Channel, Old Pass Lagoon, Lagoon Channel, Lagoon, and Old Pass Channel.

1951-present: 6 ft deep, 100 ft wide, 2,000 ft long channel, extending from the main East Pass Channel south of the Hwy 98 bridge into Old Pass Lagoon. This became part of the Federal project in 1951, although it was dredged at various times between 1930 and 1950. The bulk of the sand has been removed from the entrance to the lagoon, immediately north of the northern tip of Norriego Point. Privately funded dredging has also been performed in the Lagoon and in the entrance channel; these data are unavailable and have not been included in the table.

(Sheet 3 of 3)

> military establishment, the Eglin Air Force Base. Ordinarily it would appear that the required work, if and when needed by the Air Force, should be accomplished with funds made available to that agency and not under river and harbor law. However, it is understood that commercial and recreational vessels would make considerable use of the deepened channel and would benefit sufficiently therefrom, through reduced operating costs and more ready access to a harbor of refuge, to justify adoption of the proposed improvement as a Federal project.

This quote is significant because it underscores the military uses of the inlet. At this time, Destin's population was still only 318, and commercial fishing boats had drafts of less than 6 ft. A 6- by 100-ft channel south of the highway bridge and extending into Old Pass Lagoon was also proposed. The project was authorized by PL 193 of the 82nd Congress, 1st session, on 24 October 1951.

During the 1950's, vessel traffic through East Pass ranged from 4,000 to 6,000 trips per year (US Army Engineer District (USAED), Mobile 1963). Despite the dredging of the deeper channel, East Pass was considered to be generally unsatisfactory for navigation. Shoaling was rapid, and channel depths reverted to 7 or 8 ft shortly after each dredging. When winds were from the south, waves breaking on the bar at the edge of the ebb-tide shoal endangered vessels of all sizes and often prevented them from entering the inlet. During storms, the closest refuges were about 50 miles away in Pensacola or Panama City.

To enhance navigation and reduce the annual maintenance, the 1963 Survey Report proposed that jetties be built to protect the mouth of East Pass (USAED, Mobile 1963). The River and Harbor Act of 27 October 1965 (PL 89-298, 89th Congress) authorized modification of the existing project, and a General Design Memorandum was submitted on 9 June 1967 (USAED, Mobile 1967). The cost of the work was estimated to be $1,607,000, of which local interests would pay $482,000. Construction began in December 1967 and was completed in January 1969 (USAED, Mobile 1982). Total cost for construction, engineering and design, and supervision and administration was $980,000. Dredging of the basin and channel was an additional $263,000 (data from Annual Reports of the Chief of Engineers on Civil Works Activities, 1968 and 1969).

History of Jetties and Present Project, 1969-1990

Jetty design and construction

The East Pass jetties were a converging design, with the seaward ends at about the -6 ft mean low water (MLW) contour and the opening 1,000 ft across (Figure 3). They were similar in concept to the Corps of Engineers jetties at Masonboro Inlet, NC, and Perdido Pass, FL, in that a weir was incorporated in one of the jetties to allow littoral drift to enter a deposition basin. A dredge, working in the shelter provided by the jetties, could use the sand in the deposition basin to renourish the downdrift beach. The weir would also reduce the amount of sand that accumulated on the updrift side. As long as the deposition basin was regularly dredged, the disruption of the net longshore drift caused by the structures would be minimized. At East Pass, the weir was placed in the west jetty near the landward end. The deposition basin was dredged to provide a 300,000-cu yd volume, enough to accommodate an estimated 2-year supply of sand.

The west jetty was 4,850 ft long. It consisted of a sand dike 1,200 ft long at the landward end (Santa Rosa Island), 900 ft of rubble mound, 1,000 ft of sheet-pile weir, and 1,750 ft of rubble mound at the seaward end (Sargent 1988). The 10-, 14-, and 18-ft-long concrete sheet-pile weir sections were placed with their tops at -0.5 ft MLW. They were interlocked with tongue-and-groove joints and were reinforced with steel cables. Reinforcing 12- by 12-in. timber wales were bolted to the tops.

The 2,270-ft east jetty consisted of 1,270 ft of sand dike, followed by 1,000 ft of rubble mound. For both jetties, armor stone sizes were based on depth-limited wave conditions for a +6-ft storm surge superimposed on a 12-ft water depth. Maximum wave height used for design purposes for the jetty heads was about 14 ft (Snetzer 1969). A total of 61,000 tons of cover stone and core stone and 24,200 tons of blanket material were placed. Overall, the jetty design and choice of stone size has proven to be successful, with only minor damage over the last 20 years.

Predicted effects on physical processes at East Pass

It is useful to examine three predictions of how physical processes would be affected by the jetties. The first concerns sediment bypassing and dredging. Because of the rapid shoaling on the ebb-tidal shoal, the Mobile engineers considered it impracticable to maintain by dredging alone a safe, dependable channel at least 12 ft deep throughout the year. By ending the jetties at the 12-ft contour, the required dredging would be greatly reduced. In the 1963 Survey Report, they assumed that the longshore drift was from east to west and stated:

Figure 3. Aerial photograph of the East Pass Area, 28 June 1987; one of a series taken during the East Pass monitoring project

After the impounding capacity of the east jetty is reached, estimated to take about 12 to 15 years, a portion of the littoral material will be carried into the inlet on flood tide and the remainder may be expected to escape past the inlet and continue its movement to the west. At that time the amount of dredging required to maintain project dimensions is expected to increase but the amount required to maintain the downdrift beach would be somewhat less. The average annual dredging which would be required to satisfy all project needs cannot be determined precisely; however it is estimated that the amount would not exceed 100,000 cubic yards (USAED, Mobile 1963, p C-6).

Although the jetties as built ended at the 6-ft contour, much of this prediction has been remarkably prescient. The 1968 to 1988 dredging rate has been 97,000 cubic yards/year for the combined East Pass and Old Pass channels. In this respect, the project has certainly performed as expected. Sonu and Wright (1975) and Stone (1990) believe that east-to-west sediment bypassing does occur around the ebb-tidal shoal, although the direction of the predominant drift in this region remains a controversial matter and the quantity of sand bypassed remains unknown.

A second prediction, that some erosion of Norriego Point could be anticipated, has also been accurate. In a design conference held in the Office of Chief of Engineers (OCE) on 25 April 1967, OCE and Coastal Engineering Research Center (CERC) representatives reported that, "It is recognized that some erosion can be expected along the existing sand spit located immediately seaward of Destin Harbor and that the spit will have to be nourished by dredging after erosion takes place." During the 1980's and 1990's, the sand spit eroded severely and has been renourished many times. The continuing expense of this work is one of the reasons for sponsoring this Monitoring Completed Coastal Projects (MCCP) study.

The third prediction concerned the fate of the shoal at the end of the jetties. The jetties were to terminate at about the location of the 6-ft contour rather than the 12-ft depth as originally proposed. The shoal had built seaward during the mid-1960's, presumably as a result of dredged material being placed at the edge of the bar. "It was the opinion of the conferees that when the project proposed at the conference was completed, the shoal would disappear and the 12-ft contour revert approximately to its original position" (USAED, Mobile 1967, p 5).

This statement is difficult to evaluate. Did the conferees believe that the growth of the shoal was entirely the result of the deposition of dredged material? Large ebb-tidal shoals existed off the mouths of both the pre-1928 and the present inlets. The growth of the shoal after the 1929 breach was documented in the 1938 report (US Engineer Office, Mobile 1939, Plate 4). In this case, the prediction has proven to be incorrect, and the shoal has continued to grow seaward.

Placement of the weir and subsequent history, 1969 - 1985

The weir has been a source of endless controversy regarding its placement, construction, and maintenance. The accusation "they put the weir on the wrong side" has often been leveled at the designers of the project, and there has been considerable embarrassment over what is perceived to have been a serious planning mistake. Is this accusation justified? This report will address this question in light of the overall physical processes affecting East Pass. The following paragraphs will discuss some of the background to the weir's placement and will continue the history of the project to 1990.

Net longshore drift along most of the Florida Panhandle has been reported by many researchers to be toward the west (US Engineer Office, Mobile 1939; Stone 1990). Nevertheless, in the vicinity of East Pass, the configuration of Santa Rosa Island and the eastward movement of the inlet suggested that the net drift might be to the east although there might be frequent reversals (Snetzer 1969). There was enough conflicting evidence regarding the drift direction that initially weirs in both jetties were planned.[1] For unknown reason, the 1963 survey report proposed that only one weir be built in the east side. Still, the idea of two weirs remained a possibility at least as late as the OCE Design Conference of 25 April 1967:

> There is one major deviation from the Masonboro Project in that weirs and deposition basins are provided in each of the jetties at East Pass since the meager information leaves some doubt with regard to the prominent direction of the littoral drift. It was recommended by CERC in the earlier visit to the Mobile District that the two weirs be provided initially with the probability that we would want to close one of the weirs off after experience indicated the predominant direction of littoral drift.

Despite the acknowledgment that there was "meager information" about the drift, the conferees decided that one weir would be sufficient. "Representatives of CERC and OCE are of the opinion that the weir should be incorporated in only the West Jetty as the predominant direction of littoral drift is from that direction" (OCE Design Conference, 25 April 1967, Mobile District archives).

The physical design of the original sheet-pile weir proved to be inadequate. Sometime between April and June of 1969, only a few months after construction, a 100-ft section of the weir collapsed, and a deep scour trough formed through the breached section. A temporary repair was made by blocking all of the weir with 67,000 cu yd of sand pumped from the deposition basin, but by March 1970 this sand was gone. A permanent repair was made from June to September 1970 by building a rubble-mound weir. Three-ton stone was placed along the weir axis, and the crown elevation was -0.5 ft MLW. This renovation cost $203,000 (Sargent 1988).

The deposition basin had filled by July 1971. Opinions regarding the source of this sand and the direction of the longshore drift, as reported in the letters and memoranda of the time, are conflicting and confusing. In 1972, it

[1] Personal Communication, 1990, Francis F. Escoffier, Civil Engineer, retired, USAED Mobile, Mobile, AL.

was reported that the project was a failure and that the east jetty was practically ineffective in impounding any of the westward-moving drift (USAED, Mobile 1972). The deposition basin was dredged only one more time, in February of 1972. The records are not clear as to why regular maintenance dredging of the basin, as specified in the original project plans, was abandoned. Mr. J. Richard Weggel of CERC wrote, "The deposition area adjacent to the west jetty has been allowed to fill since it provides for attenuation of the waves crossing the weir and has thus decreased wave action on the spit" (Memorandum for Record, 18 November 1980, Mobile District archives). The 1982 Reconnaissance Report states that the basin was dredged only once because of funding limitations (USAED, Mobile 1982). Possibly the practice was also influenced by the perception that the project had failed and that the weir served no purpose.

In the early 1970's, Destin residents complained that the weir was allowing high waves to enter the inlet and cause erosion of Norriego Point and the western tip of Moreno Point. Mr. John Ingram, the Panama City Area Engineer, recommended in a Disposition Form dated 16 March 1973 (Mobile District archives) that the weir be closed. The Old Pass Channel immediately north of Norriego Point was shoaling very rapidly, and the popular opinion of the day was that the waves crossing the weir caused this problem by eroding the shore of the peninsula. A conflicting opinion was provided by Mr. Robert Jachowski of CERC, after inspecting the site from the air and the ground on 13 December 1973. His opinion was that, "The weir jetty system appears to be performing the task for which it was designed" (trip report dated 15 January 1974, Mobile District archives). He also commented, "The erosion of the sand spit should be treated as a separate problem."

Despite Mr. Jachowski's views, pressure mounted to permanently close the weir. This recommendation was presented in the 1982 East Pass Reconnaissance Report (USAED, Mobile 1982). It noted that since construction of the jetties, the navigation channel had steadily shifted toward the east within the jetty system. The report also concluded, "However, it should be noted that there will be periods when the pass is unsafe to all craft, regardless of actions taken as a result of this report" (USAED, Mobile 1982, p 8). The weir was finally closed in 1985 when it was covered with a rubble-mound trunk section identical to that used for the rest of the west jetty.

East shore erosion, jetty rehabilitation, and spur jetty, 1977 - 1990

Erosion of the eastern shore of East Pass was so serious that a design report on shoreline improvement and dune stabilization was submitted to the South Atlantic Division Engineer on 15 April 1977, calling for the construction of six rubble-mound groins near the northern end of Norriego Point (USAED, Mobile 1977). The report stated that the most severe erosion was caused by wind-generated waves passing through the jettied entrance from the Gulf of Mexico and that boat-generated waves contributed to the problem. The authors did not mention the weir as being a factor, and the refraction diagrams prepared for the report did not show any wave rays passing over the weir. The groin proposal was not approved.

General rehabilitation of the project was performed in 1977 for $278,000 (Sargent 1988). A major part of this effort was the construction of a 300-ft-long rubble-mound spur at the landward end of, and perpendicular to, the east jetty (Figure 3). The purpose of this groin was to divert the flow of the inlet's water away from the landward end of the east jetty because the beach immediately to the north had been cut back. If the erosion had continued, it was feared that the main jetty would be undermined. Ironically, the inlet was behaving as if it were trying to reoccupy a northwest-southeast-trending channel that it had followed in the 1950's and 1960's which had been specifically blocked by a sand dike when the east jetty was built (details of the inlet's meanderings will be discussed in Chapter 3).

In the 1980's, deep scour holes developed near the tip of the spur. By February 1987, one hole was deeper than 60 ft. It was filled with dredged sand and capped with concrete rubble in 1988, but the repair proved to be temporary. In February 1990, this author observed that the hole was already over 40 ft deep. In addition, the spur jetty was only 200 ft long, having lost 100 ft during the previous winter months. By March 1991, more of the spur jetty had failed, and only 100 ft remained above water level. It is fortunate that the proposed groins along Norriego Point were never built as they probably would have suffered similar scour and damage.

Monitoring Project at East Pass

Because of the many questions surrounding the performance of the jetties and the weir, Headquarters, US Army Corps of Engineers, Washington, directed that detailed monitoring be performed before and after the weir was closed to determine the effects of this action. In addition, a re-evaluation of the project dimensions was ordered. In a letter dated 29 June 1983, Mr. C. G. Goad, Chief, Operations and Readiness Division, Directorate of Civil Works, wrote to the Commander, South Atlantic Division, "Before proceeding with any extraordinary maintenance measures, you should verify that full project dimensions are necessary and justified." He also suggested, "It may be that the most efficient use of resources would be to reduce the scope of maintenance and provide a channel of lesser dimensions that would be suitable for recreational vessels." This author is unaware of whether a study was ever conducted to re-evaluate the need for a 12-ft channel.

The original goals of the monitoring effort are unclear, and there was considerable confusion surrounding what agency was in charge of the effort, what field measurements were needed, and what product was expected. Nevertheless, current and tide monitoring was conducted at East Pass during

October 1983 by personnel from CERC and Mobile District, and more data were collected in May 1984.

East Pass was included in the MCCP program in 1984. A Monitoring Program was prepared jointly by CERC and Mobile District in 1986 (USAED, Mobile 1986). A final field study was performed in April 1987. Results from this and the previous studies will be discussed in this report.

2 Geography and Geology of East Pass

General

East Pass, the only direct entrance from the Gulf of Mexico into Choctawhatchee Bay, is located on the northwest coast of Florida 45 miles east of Pensacola and 50 miles northwest of Panama City (Figure 1). Its latitude and longitude are 30°23' N and 86°31' W. The pass lies between Santa Rosa Island on the west and Moreno Point on the east (Figure 2). Santa Rosa Island is a long, narrow barrier beach that extends about 45 miles along the coast from East Pass to Pensacola Pass. Santa Rosa Sound, immediately north of the barrier island, is a natural waterway connecting Pensacola and Choctawhatchee Bays. For 4 miles to the west of the pass, Santa Rosa Island is part of Eglin Air Force Base (AFB) and has remained mostly undeveloped. Moreno Point is the western tip of the peninsula that separates the greater part of Choctawhatchee Bay from the Gulf of Mexico. The town of Destin is located on Moreno Point, which has elevations of up to 25 ft. The east side of the pass near the jetties consists of a sand spit, known as Norriego Point, which formed in 1935. This spit and the low beach immediately to the east have been developed with condominiums since the 1970's.

Choctawhatchee Bay

Choctawhatchee Bay, landlocked except for East Pass and Santa Rosa Sound, has an area of about 122 square miles, including the tributary bayous. It is about 30 miles long east to west and averages 4 miles in width. Sixteen square miles of the bay are over 30 ft deep, and some depressions are 40 ft (US Congress 1950). Santa Rosa Sound enters the southwest end of the bay, and the Intracoastal Waterway Canal to St. Andrews Bay enters at the east end. Garniers, Boggy, Rocky, and La Grange Bayous flow into the north side of the bay and the Choctawhatchee River into the east side. The latter river is 175 miles long and drains 5,200 square miles in west Florida and southeast

Alabama. It is heavily loaded with silt and clay sediments, which are being deposited in a delta at the eastern end of the bay.

The land north of Choctawhatchee Bay rises to elevations of 50 ft within a few thousand feet of the shore. In this area, MacNeil (1949) has recognized the post-Wisconsin Silver Bluff shoreline at an elevation of about 8 to 10 ft. The Pamlico shoreline at 25 to 35 ft represents the mid-Wisconsin glacial recession. These marine terraces overlie the thick fluvial blanket of sands, clays, and gravels of the Citronelle formation. The exact age of the Citronelle is unknown, but MacNeil (1949) inferred it to be early Pleistocene. All of the present bays in western Florida--St. Andrews, West, Choctawhatchee, and Pensacola--were larger in Silver Bluff time. The Silver Bluff age can be tentatively correlated with a period 6,000 to 4,000 years ago when the climate was warmer than it is now, therefore representing the peak of the Recent interglacial stage.

Salinity at the bottom of Choctawhatchee Bay ranged from 22 to 30 o/oo (parts per thousand) in June 1965 (Goldsmith 1966). Salinity may be highly variable because during storms the rivers can supply a significant amount of fresh water into the bay (US Army Engineer Office, Mobile 1939). Also, freshwater springs flow into the bottom.[1]

A wide shoal along the edge of Choctawhatchee Bay contains primarily coarse sand, while silt is the dominant sediment in the deeper parts of the bay. A large sand area in the southwest corner of the bay, north of Santa Rosa Island, is of notable interest because it is probably a relict sand deposit (Goldsmith 1966). The quartz grains are yellowish, rounded, and well-sorted, all suggestive of "old" reworked sediments. This is in contrast to the clean white, angular grains found in East Pass and along the shorelines facing the Gulf of Mexico.

Much of the sand surrounding Choctawhatchee Bay is semicemented or impregnated with a dark-brown to black water-soluble material known as humate (Swanson and Palacas 1965). The organic humate compounds, coal-like in composition and appearance and derived from the leaching of decaying plant and animal debris, were carried in colloidal suspension by streams and were later flocculated or precipitated from these waters upon entering a different chemical environment. This different environment may have been caused by an increase in salinity where the ancestral East Pass let salt water enter the bay. Over time, significant quantities of humate accumulated in the bay. The humate-cemented sand is typically about 3 ft thick but may be as much as 15 ft in some areas. A medium- to dark-brown firmly cemented sand "pavement" or ledge 3 ft thick is exposed in many areas along the shore of the bay. The humate accounts for the very dark water of

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[1] Personal Communication, 1990, Francis F. Escoffier, Civil Engineer, retired, USAED, Mobile, Mobile, AL.

Choctawhatchee Bay. On the ebb tide, the dark water exiting East Pass is opaque to aerial photography.

Santa Rosa Island

Santa Rosa Island is the second longest (50 miles) barrier island on the gulf coast, but averages only 1,000 to 1,500 ft in width (Otvos 1982). Dunes up to about 40 ft high occur on the western end of the island, but near East Pass elevations are less than 30 ft. During storms when the water is high in Choctawhatchee Bay, parts of the island north of Highway 98 are inundated. The Holocene quartz sands are between 15 and 30 ft thick and are interpreted by Otvos (1982) as being a veneer of shoreface, dune, and beach deposits that overlie a Pleistocene core. Near the tip of the west jetty, rotary drill cores recovered brown, poorly graded sand with silt content at a depth of about 39 ft (Mobile District archives). This brown sand may represent the top of the Pleistocene surface. Stone (1990) considers Santa Rosa Island to be a typical foredune--barrier flat complex along its entire length. Possible relict flood-tide shoals in Santa Rosa Sound suggest that the present island may have been a series of smaller ones at some time. The openings were likely short-lived as both Stone (1990) and Tanner (1964) believe that there has been an ample supply of littorally reworked sediment available during the Holocene.

Only limited borehole information is available from the vicinity of the inlet, and there are no known seismic data. Along the route of the highway bridge, 10 cores were taken by the Florida State Highway Department in 1932 (US Engineer Office, Mobile 1939). The logs show a 5- to 8-ft layer of "sand and blue gumbo" and "sand and muck" extending across most of the present inlet at depths of -30 to -40 ft. Sand was found above and below the gumbo. This layer presumably is organic-rich lagoonal deposits, suggesting that the inlet has not always occupied this site.

Immediately west of East Pass, a series of northeast to southwest-oriented recurved beach ridges suggest that this part of Santa Rosa Island grew from west to east during the Holocene. This growth may be the result of localized longshore drift to the east. The long-term drift direction in this area continues to be controversial and will be discussed later in this report.

Moreno Point (Destin)

Moreno Point peninsula, previously mapped as the Silver Bluff shoreline (MacNeil 1949), has an elevation of up to 25 ft and may be part of a relict barrier island formed during the peak and regressive phases of the Sangamonian (about 125,000 years B.P.) (Stone 1990). No core data are available. East of Destin, facing the Gulf of Mexico, the oxidized orange Pleistocene bluffs rise about 12 to 15 ft above the clean white Holocene beach.

Between Grayton Beach and Destin, a series of Holocene baymouth barriers have effectively sealed off a number of small bays, former stream valleys that were incised during the late Wisconsin low sea level. The wide sandy beach to the east of the inlet and south of Old Pass Lagoon was part of Santa Rosa Island before the present channel was cut in 1928. Since the 1970's, it has been developed with canals, roads, and multifloor condominiums.

Physical Oceanography

Deepwater circulation in the eastern Gulf of Mexico is dominated by the highly variable Loop Current (Huh, Wiseman, and Rouse 1981). The general circulation of the Loop Current is clockwise. Advanced Very High Resolution Radiometry (AVHRR) satellite images reveal that gyres or eddies break off from the Loop Current (Huh, Wiseman, and Rouse 1981; images processed by the author in 1991) (Figure 4). Some of the eddies (red color in Figure 4) spin clockwise and some spin anti-clockwise. Interactions between these eddies and northeastern gulf slope and shelf waters are not well understood, but it appears that nearshore coastal waters are either mixed with or entrained by Loop Current waters during periods when the Loop intrudes north of 29 deg N latitude. This speculation is supported by observations of floating buoys, which broke loose from their moorings off Mobile bay and were subsequently recovered in the Florida Keys (Schroeder et al. 1987). An additional factor, of unknown importance, may be caused by DeSoto Canyon, which has been observed to funnel warm, saline offshore water shelfwards (Huh, Wiseman, and Rouse 1978).

Despite the occasional influence of the Loop Current, recent research (cited in Schroeder et al. 1987) suggests that the circulation along the continental shelf region between DeSoto Canyon (south of Choctawhatchee Bay) and the Mississippi Delta is primarily wind-driven and is modified by flows associated with freshwater runoff-imposed density gradients. Nearshore pressure gradients, set up by runoff from the numerous rivers flowing into the northeast Gulf of Mexico, drive a westward geostrophic flow near the coast. In the summer, weak southeast winds drive a weak west current, which enhances the geostrophic flow. However, even in summer, changes in wind direction can cause the nearshore currents to reverse and flow eastward.

During the winter, the climate is dominated by the passage of cold fronts, which result in highly variable nearshore currents. The cold fronts pass the area between October and April on a 3- to 10-day cycle (Huh, Rouse, and Walker 1984). The fronts induce strong latent, sensible, and radiative heat

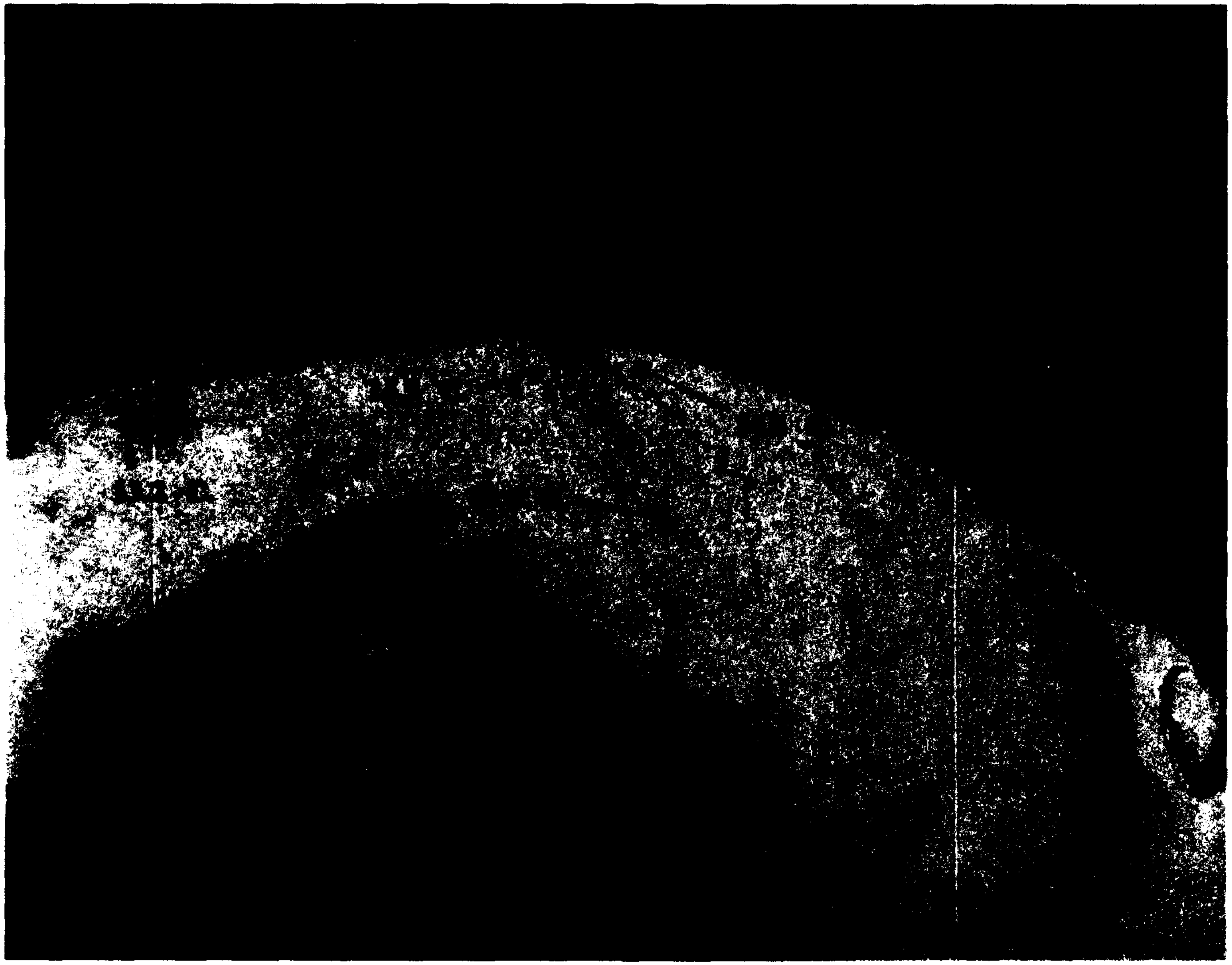

Figure 4. Northeast Gulf of Mexico, 25 February 1990. NOAA 10 satellite, AVHRR line scanning multispectral radiometer, Channel 4 (10.5-11.5 μm wavelength). The dark plume at the bottom of the image is an intrusion of warm loop current water. Data captured by the Earth Scan Laboratory, Coastal Studies Institute, Louisiana State University (LSU), Baton Rouge, LA. Image processed by the author at LSU.

fluxes from the warm sea to the cold atmosphere. The first few fronts of the season produce especially intense water mass transformations because the seafloor and strong density gradients limit the volume of water available for mixing.

The cold-front cycle includes three phases: prefrontal, frontal passage, and cold-air outbreak. The prefrontal phase has a falling barometer, strengthening of southerly winds, and onshore advection of warm, moist air. The southerly winds cause fully developed, long-fetched seas, and sea level setup along the coast. The frontal passage and the subsequent cold-air outbreak abruptly reverse these conditions. Strong northeast winds and clear skies cause intense energy transfer from the warm water to the cold air. Nighttime cooling of the coastal land mass maximizes temperature and pressure differences between land and sea, intensifying the predominant offshore winds. The result is that the high seas generated during the prefrontal phase are set down within 24 hr after the frontal passage and water level drops as shelf water is pushed offshore (Huh, Rouse, and Walker 1984).

Research conducted along Louisiana's coasts suggests that stormy conditions associated with the periodic cold-front passages may have greater cumulative geologic effects than the occasional, more violent hurricanes (Roberts et al. 1987). Significant sedimentological and geomorphic changes in the Mississippi Delta's coastal and nearshore shelf environments are forced by winds, waves, and currents generated by the succession of winter cold-front cycles. Although the cold-front passages are of lower energy than the more violent tropical cyclones, the fronts' more uniform direction of approach, repeated pattern of wind changes, large spatial scales, and higher frequency (30 to 40/year) result in greater cumulative long-term changes. It is possible that the cold fronts also are the dominant factor causing long-term geologic change in the shorelines and nearshore along the Florida Panhandle. Further research to identify these changes would provide valuable insights to an understanding of physical processes along the northwest Florida shore.

Tidal range along the Florida Panhandle is typically less than 2.0 ft. The tide is diurnal, but varies in a complex manner and at times is semidiurnal (US Department of Commerce 1990). Plots of the tide elevations measured in this project will be presented later in this report.

The effects of hurricanes on the wave regime in the eastern Gulf of Mexico are not known. Between 1886 and 1970, 12 hurricanes (defined as winds of 33 m/sec or greater) made landfall near Pensacola and 6 near Panama City (Simpson and Riehl 1981). During this interval, no great hurricanes (winds of 56 m/sec or greater) made landfall in this area. Based on these historic data, the probability for a hurricane strike in the Pensacola area is 14 percent, and for the Panama City area 7 percent. No probabilities are calculated for great hurricanes (Simpson and Riehl 1981).

Longshore Drift

There has been controversy in the scientific literature about the predominant drift direction in the vicinity of East Pass. Many researchers have considered it to be westerly along the western Florida Panhandle (Kwon 1969; Wright and Sonu 1975; USAED, Mobile 1963). Stone (1990) believes that the Pleistocene headland east of Destin is the primary source of sand along this part of the coastline and that net transport is westwards towards Pensacola. Published estimates of the amount of net drift vary considerably, as listed in Table 2.

Table 2
Longshore Drift Estimates, East Pass, Florida

Reference	Net Quantity (cu yd/yr)	Direction (Towards)	Quantity West (cu yd/yr)	Quantity East (cu yd/yr)	Notes[1]
USAED, Mobile (1963)	65,000	West	130,000	65,000	Pensacola dredging
Gorsline (1966)	78,500	West			
Stone (1990)	52,000	West			WIS - WAVENRG
Stone (1990)	65,400	West			USN - WAVENRG
Walton (1973)	254,000	West	361,000	107,000	SSMO

[1] WIS = Wave Information Study; WAVENRG = wave energy distribution computer program; USN = US Navy; SSMO = Summary of Synoptic Meteorological Observations.

East of Destin, near Panama City Beach, Florida, Wang et al. (1978) estimated by the fluorescent tracer method that net transport was 210,000 cubic yards/year to the west.

Under the scenario that the net drift is to the west, the dynamic behavior of East Pass implies that it is migrating updrift. Updrift migration has been reported in the literature (Aubrey and Speer 1984, Carter 1988, FitzGerald 1988). An alternative scenario is that there is a localized drift reversal in the vicinity of East Pass. Levin (1983) noted that there was geological evidence of an anomalous eastward sediment transport in this region. The southwest-northeast orientation of the beach ridges on the eastern end of Santa Rosa Island (Figure 3) indicate that this part of the island grew from west to east.

Based on the wave data collected during this study, this author hypothesizes that a nodal point exists in the East Pass area and that frequent drift reversals occur. Since the predominant wave approach is almost perpendicular to the shoreline, small deviations about this direction caused by changing meteorological conditions may be enough to cause the reversals.

This conclusion is essentially the same as that of Tanner (1964), who postulated that drift to the east and to the west met at a locus somewhere between Panama City and Pensacola. Subtle changes in wave climate would cause this locus to move back and forth.

3 Geologic Model of Inlet Behavior

Phase 1: Pre-1871 to 1928

The historic behavior of East Pass inlet can be described in terms of a three-phase model, based on models described by FitzGerald (1988) for tidal inlets along the east coast of the United States.

The first phase, characterized by inlet migration, is of spit development and breaching (Figure 5). This usually occurs in a mixed-energy (neither wave- nor tide-dominant) environment where the migration of the tidal inlet results in an elongation of the inlet channel. Under these conditions, if the spit is breached during a catastrophic storm, the new inlet, which is shorter,

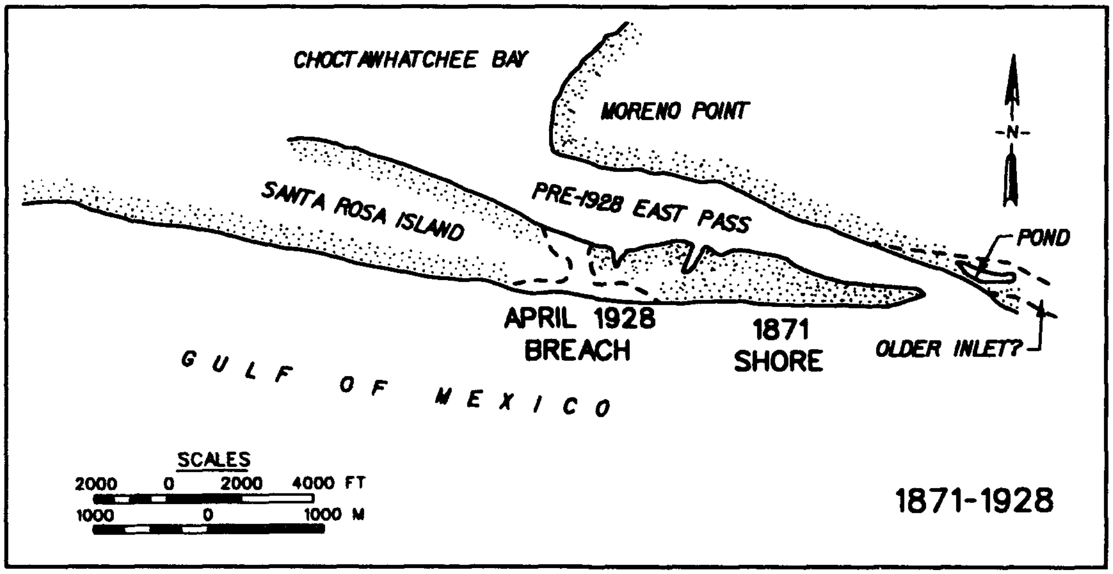

Figure 5. Pre-1871-1928 East Pass Inlet, based on Plate 4 from US Engineer Office, Mobile 1939

will normally stay open while the less efficient older inlet gradually closes. By this process, the older inlet becomes an elongated pond that parallels the shoreline.

Historic records indicate that East Pass inlet has abutted Moreno Point since the 1820's. Whether the pass ever occupied a location farther to the west is unknown. Historic information suggests that Moreno Point has been relatively resistant to erosion. John Williams' 1827 map is not accurate enough to use for shoreline analyses, but the shape of the peninsula on his map is contemporary, and a large flood-tide shoal is depicted in the same position as the present one. Some erosion of the western tip of Moreno Point has occurred since 1871, but the south side, facing Old Pass, is essentially unchanged. Additional evidence that Moreno Point did not extend much farther west is provided by the cores taken along the highway bridge, which suggest that there are lagoonal deposits here between 30 and 40 ft below the present MLW.

Although the northern end of the inlet has been anchored by Moreno Point, the seaward end has migrated back and forth. Before 1928, East Pass ran in a northwest-southeast direction and entered the Gulf of Mexico about 1.5 miles east of its present mouth. A brackish pond about 0.5 mile east of the eastern end of the present Old Pass Lagoon suggests that in the past the inlet extended at least 2 miles east of its present location.

Santa Rosa Island was breached in April 1928 during a heavy rainstorm at about the location of the present inlet (US Congress 1950).

Phase 2: 1928 to 1968

This phase is characterized by stable throat position but a main ebb channel that migrates over a developing ebb-tidal delta (Figure 6). The migration is caused by longshore drift, which causes a preferential accumulation of sediment on the updrift side of the ebb-tidal delta, resulting in a deflection of the main ebb channel (FitzGerald 1988). In some cases, as at East Pass, the main ebb channel migrates far enough downdrift so that it impinges on the downdrift shoreline, causing erosion of the adjacent beach. Eventually, the channel becomes hydraulically inefficient in this configuration, and it diverts its flow to a more seaward route through a spillover lobe channel. This sequence of events describes East Pass' behavior between 1928 and 1968, as described in the following paragraphs.

After the new East Pass Inlet was breached in 1928, the new course shoaled while the original course remained open. During the great storm in 1929, local inhabitants dug a pilot channel along the 1928 breach, which let the high water from Choctawhatchee Bay rush out to the Gulf of Mexico (Angell 1944). Record rains had fallen on Choctawhatchee Bay and its

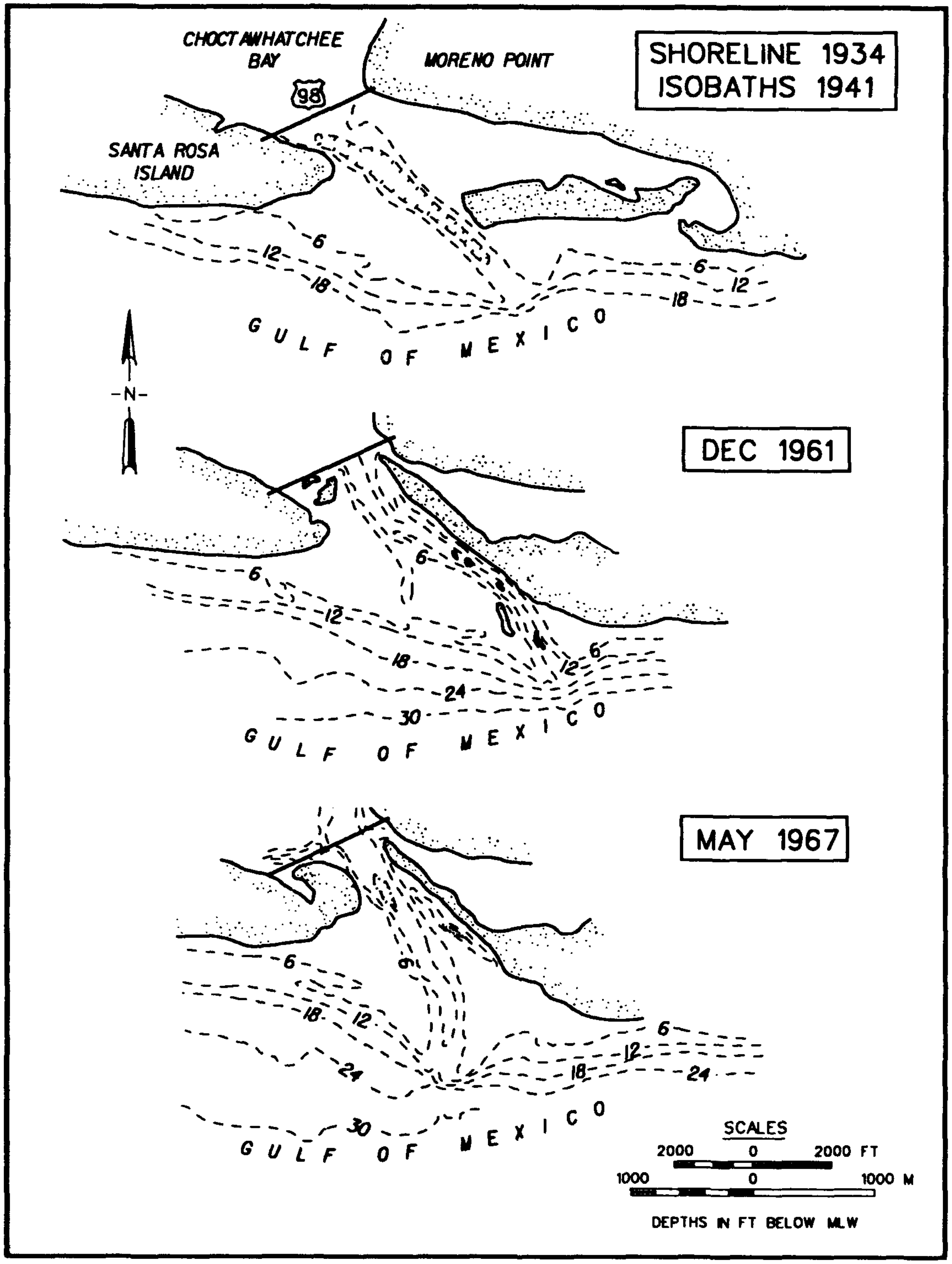

Figure 6. 1934-1967 East Pass. This covers the period after the present inlet was breached and before the jetties were built. Based on figures in USAED, Mobile (1963)

tributary rivers, with 16 in. falling in 48 hr (US Engineer Office, Mobile 1939). The rainstorm was accompanied by strong south and southwest winds. High-water marks revealed that the water levels rose to 5.4 ft above MLW near Post Washington and 4.9 ft near Valparaiso, resulting in a tremendous outflow through the breach. As this new channel was shorter and more efficient than the longer Old Pass route, it captured the tidal flow in and out of Choctawhatchee Bay. The breach widened, and by 1935 was 2,500 ft across.

The new channel cut off the eastern tip of Santa Rosa Island. Under the influence of waves and littoral drift, the gulf entrance of the old channel began to shoal, and by 1935 only a shallow, narrow opening remained. The old ebb-tide shoal eroded rapidly, and hydrographic surveys indicate that it had disappeared by 1938 (US Engineer Office, Mobile 1939, Plate 4).

Aerial photographs show that the sand spit along the east side of the inlet, now known as Norriego Point, formed in 1935. The source of sand for Norriego Point's growth appears to have been littoral drift carried into the inlet with the flood tide. Drifters released during the 1938 study traveled into the new inlet on the flood, closely following the eastern shoreline (US Engineer Office, Mobile 1939, Plate 5). In addition, some sand may have come from the erosion of the beaches adjacent to the inlet's mouth.

With the closing of the gulf opening to Old Pass Lagoon, the channel south of the highway bridge running in an east-west direction was the only access to Destin's harbor. Several times in the mid-1930's, this channel was blocked (based on aerial photographs from the archives at Eglin AFB). In August 1937, the US dredge "Blackwater" removed 39,000 cu yd of sand, deepening the channel to 9 ft. Despite this effort, by March of 1938 Norriego Point had joined to Moreno Point, completely closing the entrance to Old Pass Lagoon again (US Engineer Office, Mobile 1939). Photographs from 1943 and 1944 show the channel from Old Pass to the main inlet to be open. Norriego Point was wide, and grass was growing on the dunes in those images.

By 1935, East Pass's thalweg was hugging the eastern side of the inlet, a behavior that has continued to the present. Between 1935 and 1938, the east shore moved 300 ft northeast (USAED, Mobile 1963). At the same time, Norriego Point sand spit continued to grow in width, nourished by a great influx of littoral sediment, and its orientation became more northwest-southeast as the inlet moved eastward. From 1938 to 1961, the east side of the inlet continued to move east, but at a slower rate. A comparison of vertical aerial photographs taken 21 November 1938 and 28 March 1955 shows relatively little change in the orientation of the inlet.

Between 1935 and 1938, the inlet's west side (the eastern end of Santa Rosa Island) eroded about 500 ft (USAED, Mobile 1963). Between 1938 and 1961, the end of the island remained in about the same position but became more pointed in shape. During this same time, the Gulf of Mexico shoreline eroded an average of 200 ft for a distance of 1-1/2 miles west of the pass.

The main channel's trend was northwest-southeast for over 30 years, at least through September 1960. Sometime in early 1962, a north-south overwash channel breached the ebb-tidal delta (Figure 6) (USAED, Mobile 1963, Plate 4). The formation of the overwash channel appears to have been a natural process, and there is no indication in the literature or the project maps that the new channel was initially cut with dredges. Shoals and sandbars rapidly formed between the two channels. By February 1964 (based on the hydrographic survey maps), the new north-south channel was wider and deeper than the older northwest-southeast one. An oblique aerial photograph taken in February 1965 shows a large crescent-shaped subaerial sandbar near Norriego Point with a shoal extending most of the way across the older northwest-southeast channel (Figure 7). In 1965, dredged sand was placed on the sandbar.

Phase 2 of the geologic model was artificially brought to an end with the construction of the jetties, starting in December 1967. The north-south channel was stabilized by the jetties, and the other one was blocked with dredged sand. Several ponds marked the route of the former northwest-southeast channel. One of these ponds still exists, and condominiums have been built near it.

Phase 3: 1968 to Present; Possible Future Behavior

From 1968 to the present, the inlet has been characterized by the third phase of the model: stable inlet throat and ebb channel, and ebb-tidal shoal growth. During this phase, when sand bypasses the mouth of the inlet, large bar complexes form, migrate landward, and weld to the downdrift shoreline (FitzGerald 1988). The bar complexes form from the stacking and coalescing of swash bars on the ebb-tidal delta platform. The swash bars move landward because of the dominance of landward water flow across the swash platform, creating a net landward transport of sand on both sides of the main ebb channel. The ebb-tidal platform continues to grow as long as the inlet does not migrate.

An essential question that must be addressed is how stable is Phase 3 at East Pass; if it is unstable, what physical processes are responsible?

Temporarily, the jetties have stabilized the mouth of the inlet by preventing the main ebb channel from migrating. Farther inland, however, the inlet has continued its long-term tendency to move eastward. This is confirmed by the numerous hydrographic maps made at the inlet, which show that the thalweg hugs the east shoreline. Norriego Point has eroded severely and has had to be renourished with dredged sand numerous times. Results of this study suggest that constant maintenance will be required to maintain the inlet in its present location. The condominiums, built on Norriego Point in the 1980's, are in a precarious situation. A major storm might breach Norriego Point and the low

Figure 7. February 1965 aerial photograph of East Pass taken from Gulf of Mexico looking north. The large body of water in the background is Choctawhatchee Bay. The Gulf of Mexico end of the pass has divided into two channels. The channel on the right is almost blocked with a sand bar extending from the shoal in the foreground to Norriego Point sand spit. Official USAF photograph, provided by DynCorp, Eglin AFB

beach east of the present inlet, allowing the channel to reoccupy its pre-1928 course. East Pass would thereby return to Phase 1 of the model.

Proposed Driving Forces of Eastward Migration

The remainder of this report will describe the field studies conducted between 1983 to 1990. Based on these data, the driving forces of the eastward migration are hypothesized to be the following:

a. *Wave forces.* The predominant wave direction, measured off Fort Walton Beach 4 miles to the west of East Pass from 1987 to 1990, is between 180 and 210 deg, while the shoreline trends at an azimuth of 95 deg (Figure 2).

b. *Backbay tidal channel geometry.* Two tidal channels lead from Choctawhatchee Bay into East Pass: one is to the north and the other parallels Santa Rosa Island in an east-west orientation. Ebb flow along the latter channel and over the flood-tidal shoal directs the inlet's currents to the east along Norriego Point.

c. *Differences in duration of the ebb and flood flow in and out of Choctawhatchee Bay.* Because of fresh water from the Choctawhatchee and other rivers that flow into the bay, the ebb flow through East Pass often has a longer duration and higher velocity than the flood.

4 Field Data Collection and Results

Wave Data 1987-1990

Directional wave data were collected by CERC from 1987 to 1990 at a site 4 miles west of East Pass (Figure 2). Sea Data 635-9 or 635-12 directional wave gages were mounted in a steel tripod at 31-ft water depth. The internal-recording gages were serviced by divers every 2 months, and the data tapes were processed at CERC by the author. In these instruments, instantaneous water pressure was measured with a Paroscientific quartz pressure sensor, and horizontal, orthogonal components of the water velocity were measured simultaneously with a Marsh McBirney electromagnetic current meter. The gages recorded wave bursts of 1,024 pressure, u-velocity, and v-velocity samples at a rate of 1.0 samples/second, producing 17.07-min-long time series. Wave bursts were collected every 6.0 hr. The data were spectrally analyzed on a VAX computer using a band-averaging procedure. Pressure values were converted to water heights using linear wave theory. The directional distribution of wave energy was calculated with a method described by Longuet-Higgins, Cartwright, and Smith (1963). Quality-control procedures used to validate the wave data are described in Morang (1990).

Between 1986 and 1990, gages were in the water a total of 1,240 days. Because of gage malfunctions, a total of 645 days of valid directional wave data were recorded, a data recovery rate of 52 percent (2,515 good wave bursts total). No wave data were acquired during 1986. Gage failures occurred randomly throughout the years and were not related to the severity of the weather. During processing, waves below 0.15 m high were rejected because their energy was too low to calculate realistic estimates of the directional energy distribution. As a result, 396 wave bursts, 15.7 percent, were rejected.[1] The following plots represent H_{m0} spectral wave height,

[1] A tabular summary of all valid wave data is presented in Volume II, Appendix C. Monthly plots of wave height, period, and direction are in Volume II, Appendix D. Plots of water depth and mean currents are in Volume II, Appendix E.

approximately equal to $H_{1/3}$ significant wave height in deep and transitional water depths (Horikawa 1988). Although the water depth at the East Pass measurement site was only 31 ft, this is classified as transitional for 6.0-sec waves, which are typical in this area (*Shore Protection Manual* (SPM) 1984).

From 1987 to 1990, waves were generally low, with H_{m0} height rarely exceeding 2 m. Storms were more frequent in winter but not necessarily more severe than those that occurred in summer. This part of Florida was not affected by hurricanes during the time that CERC's gages were at the site. Figure 8 is an example of the data from June 1989, during which two storms occurred. Peak period was between 4 and 10 sec. It is noteworthy that peak direction for most of the month was from the southwest, about 200 to 220 deg.

Information about the overall wave climate at the site is shown in Figure 9, which represents the distribution of wave heights, periods, and peak directions in the form of percent occurrence histograms. The bar on the right, labeled "U," represents the undefined or rejected data points (waves lower than 0.15 m). The most common wave height was only 0.2 to 0.3 m, and most periods were less than 7.0 sec. The top histogram reveals a distinct southwest orientation for most of the waves, with the most common direction being 190 to 200 deg. Although the most common direction was southwest, southeast waves were recorded throughout the year. The wave records do not reveal that the shifts in direction from southwest to southeast and back occur on a seasonal or any other detectable cycle. This is similar to the findings of Wang et al. (1978), whose examination of aerial photographs of Panama City Beach, Florida, did not indicate obvious cycles to the shifts in drift direction.

From where did the higher waves come? For waves above 0.7 m, the most common direction was 180 to 190 deg (Figure 10). For waves higher than 1.0 m, the pronounced southwest orientation was again evident, with few waves coming from the southeast (Figure 11).

It is important to stress that these results summarize only the wave climate from 1987 to 1990. They are probably representative of long-term, mild weather conditions, but no extremal statistics have been calculated, and there are no hurricane wave data for this area. It is not known what effects hurricanes have on the wave climate or the shoreline near East Pass. Hurricane Camille produced almost no effects here (Tanner 1970). An aerial photograph taken 25 September 1975, after Hurricane Eloise, reveals no detectable changes to the shorelines.

As the shoreline trends at an azimuth of 95 deg near East Pass, the 1987-90 wave direction was slightly west of perpendicular. This suggests that during these years longshore drift in this area was predominantly to the east. This conclusion is based on the assumption that longshore transport rate Q depends on the longshore component of wave energy flux in the surf zone (SPM 1984). If the incoming wave crests make an angle with the shoreline, the energy flux is in the direction of the wave advance. In the past, slight

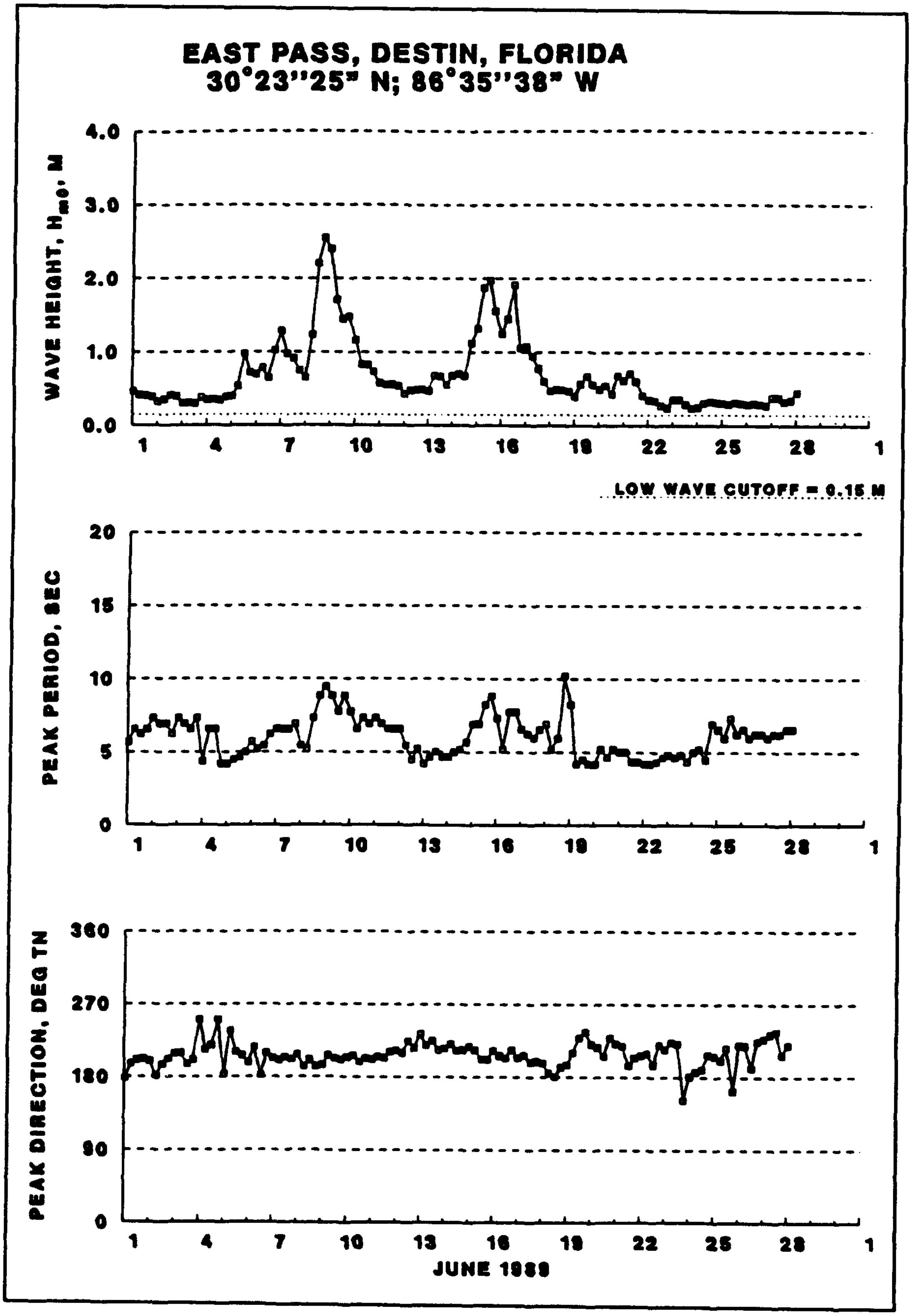

Figure 8. Summary of wave data from June 1989

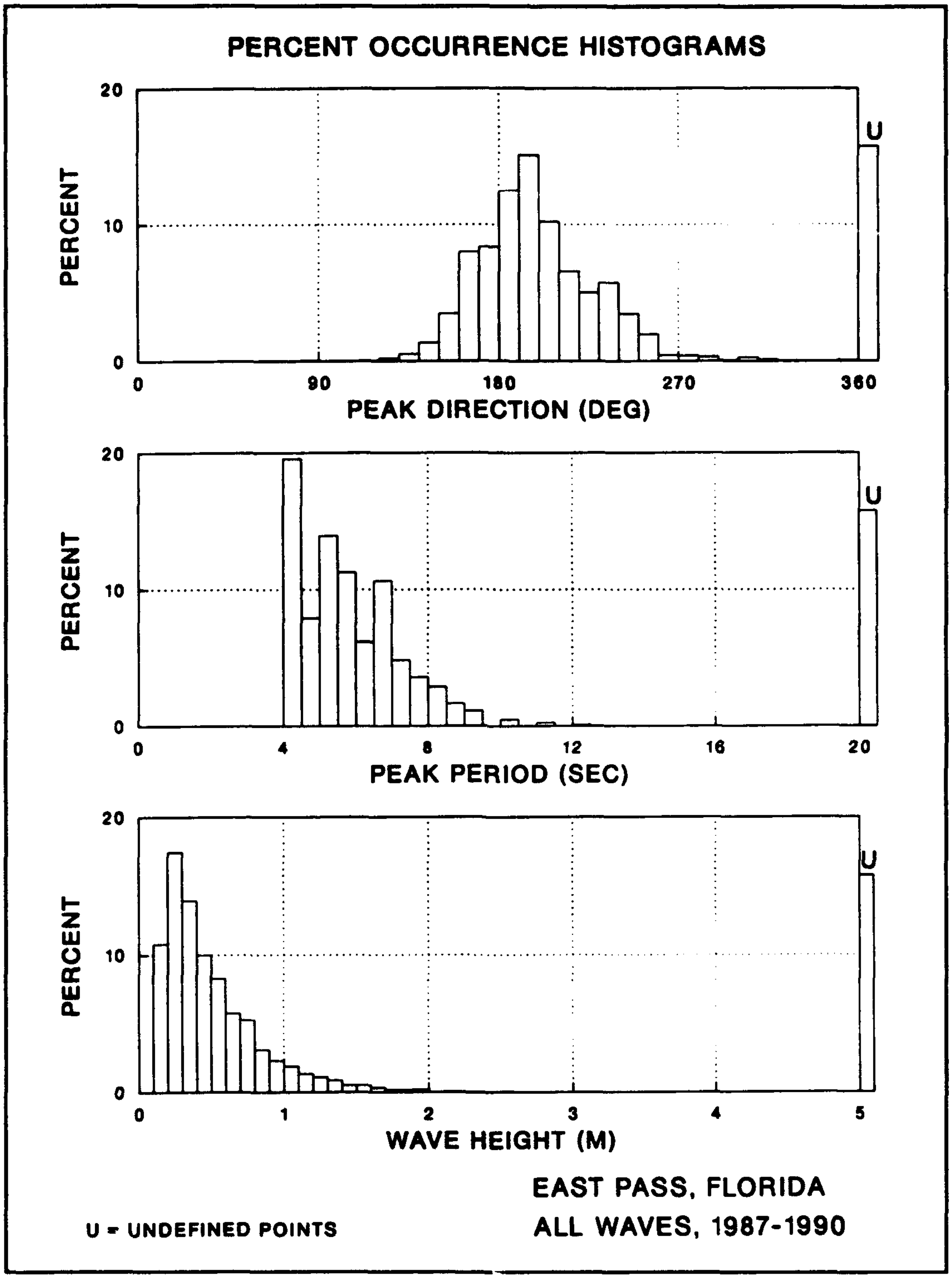

Figure 9. Percent occurrence histogram of all waves measured by CERC directional wave gage, 4 miles west of East Pass between 1987 and 1990. "U" represents rejected waves below 0.15 m high. Total wave bursts = 2,515. Rejected = 396. Predominant wave direction is from the southwest

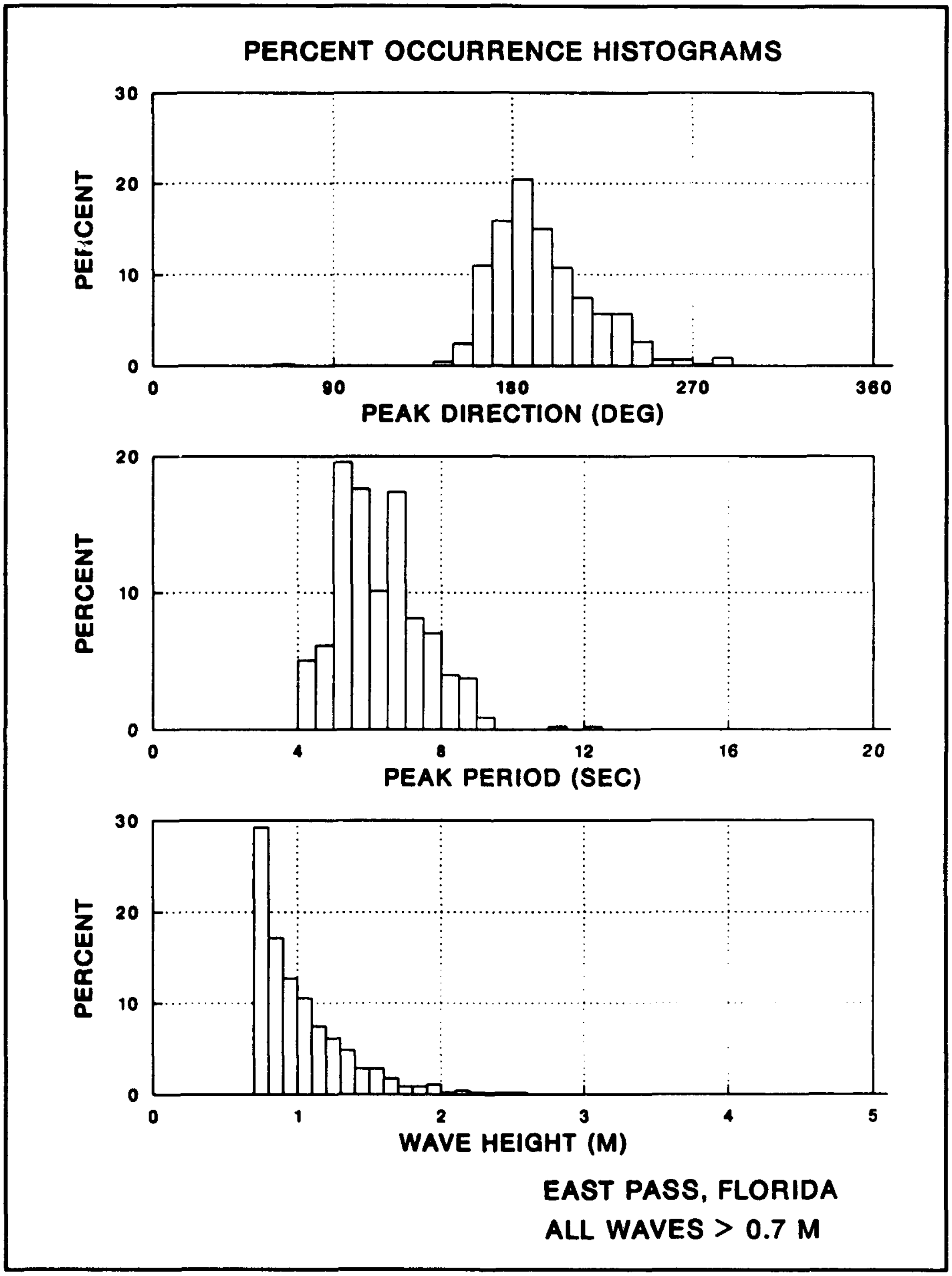

Figure 10. Percent occurrence histogram for waves higher than 0.7 m measured by CERC gage, 4 miles west of East Pass

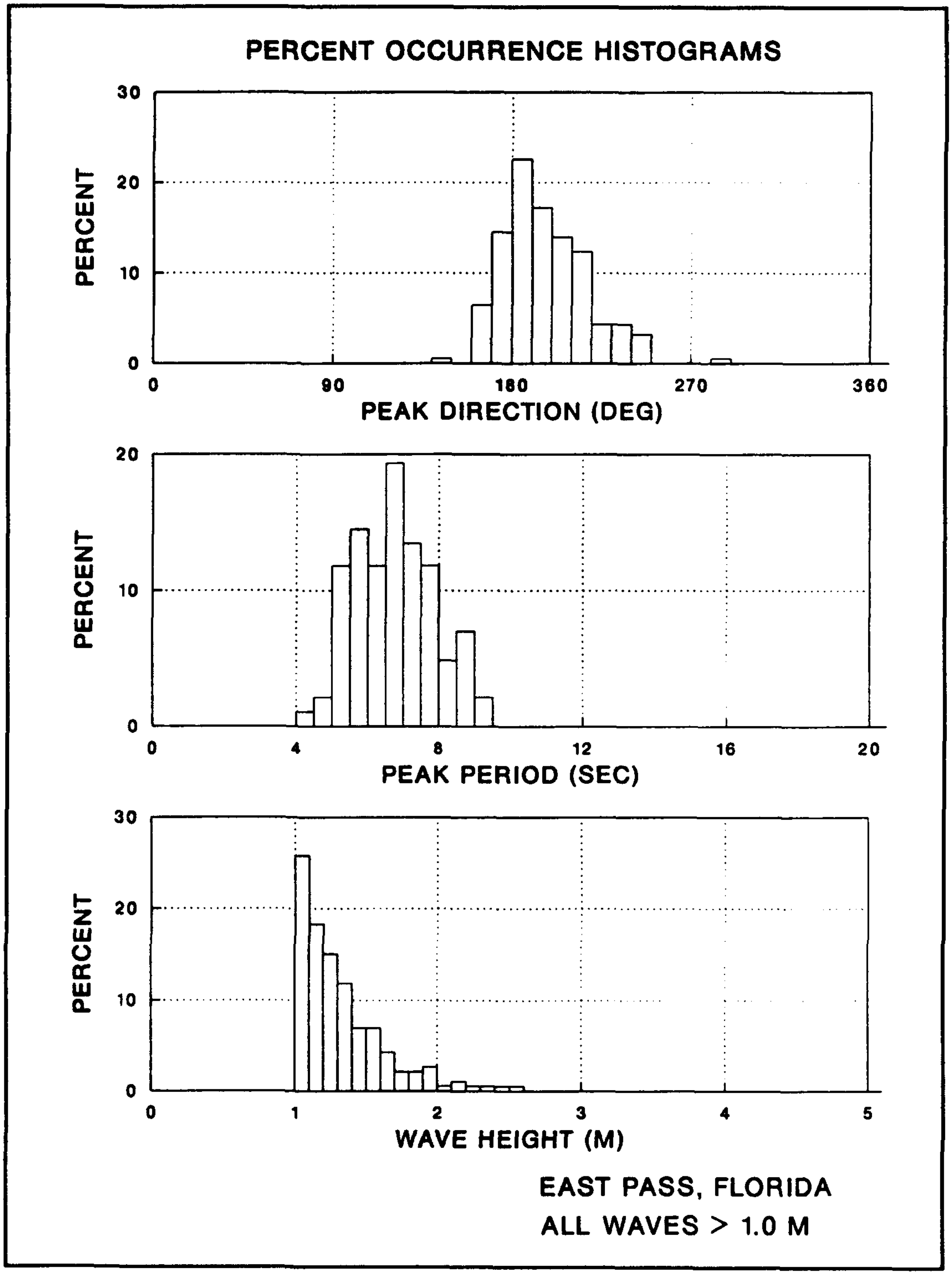

Figure 11. Percent occurrence histogram for waves higher than 1.0 m measured by CERC gage, 4 miles west of East Pass. Predominant direction is from the southwest

changes in weather patterns may have caused the wave direction to swing back and forth around the 185-deg perpendicular. This would have changed the drift direction and might account for the conflicting interpretations reported in the literature.

Ebb-Tidal Shoal 1967-1990

Of the numerous hydrographic surveys available for the East Pass area, seven were chosen for their comprehensive coverage of the shoal and the mouth of the inlet. The survey sheets were of uniformly high quality, requiring no additional depth or location corrections. All depths were referenced to MLW, and all the charts used Lambert Conformal Projection, State of Florida, North Zone Plane Coordinates. Analyses and volumetric computations were performed on VAX and Cray computers at WES using Radian Corporation's Contour Plotting System 3 (CPS3) software. The depth points from the survey sheets were digitized and used as input for CPS3's surface gridding algorithms. Contours and volumes were based on the gridded surfaces. The area gridded was a square with 5,000-ft sides (Figure 12). Eighteen 1,000-ft square polygons encompassing the present ebb-tidal shoal were used for the volumetric calculations. These squares serve as convenient references and are plotted in the subsequent figures. Manual calculations of the shoal's volume compared closely with the CPS3 ones. Based on a vertical confidence interval of ± 0.3 ft for the hydrographic surveys, the error of the volumetric comparisons is estimated to be 15 to 33 percent. The procedures used in estimating the errors are described in Appendix B.

The ebb-tidal shoal is a wide, U-shaped body of sand with a flat top and a crescentic bar at its seaward edge. Wright and Sonu (1975) identified three units to this inlet-mouth bar: the seaward-ascending back bar, the bar crest, and the steep bar front. They believed that the bar crest and front were essentially continuous with the outer bars of the adjacent coast and served as the avenue of littoral bypassing. The crest of the bar is about -10 ft MLW, while the base of the bar front is about -20 ft. Figure 13 shows the shoal in June 1967, before the jetties were built. The dots are the locations of the individual digitized depth points. The main channel extends to within 700 ft of the edge of the shoal. The steepness of the seaward bar front is shown by the converging contour lines. Figure 14 shows the shoal in February 1990. The increase in overall size since 1967 is obvious. The present navigation channel follows the depression that extends in a northeast-southwest orientation across the shoal. Although the channel had not been dredged since April 1988, it appears to have naturally remained over 10 ft deep. There are two areas of serious scour: one at the tip of the west jetty and the other around the end of the spur jetty.

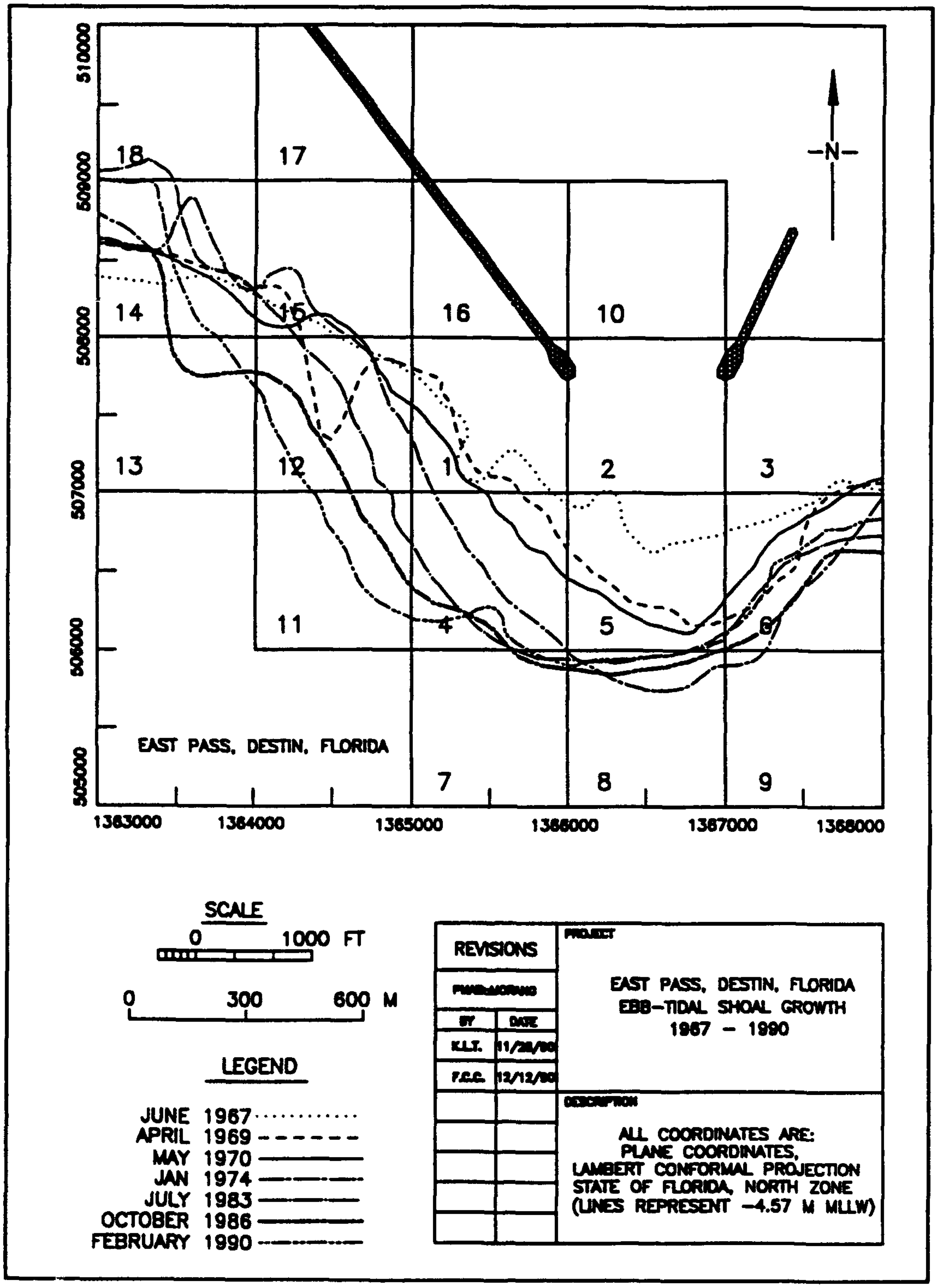

Figure 12. Area used for analysis of ebb-tidal shoal. Surface elevations computed for entire 5,000-ft square area. Eighteen 1,000-ft square polygons used for volumetric calculations. Contours, which are -15 ft MLW, approximately midway up the shoal's bar front, show the time-history of growth of the ebb-tide shoal. Since 1974, growth has been to the southwest in Polygons 4, 11, and 12

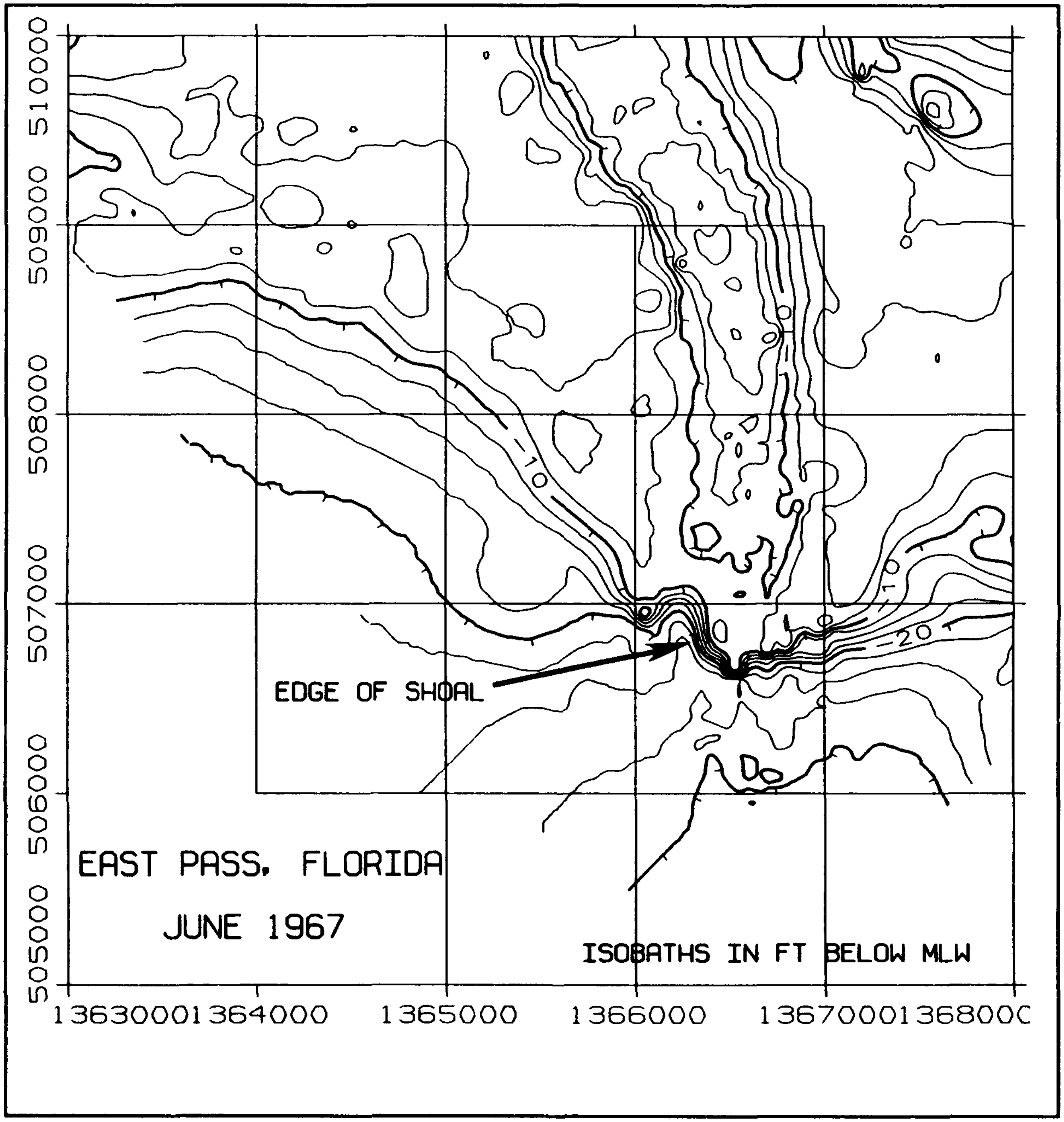

Figure 13. East Pass ebb-tidal shoal, June 1967. Depths in feet below MLW. Contour interval 2.5 ft. Surveys performed before construction of jetties commenced

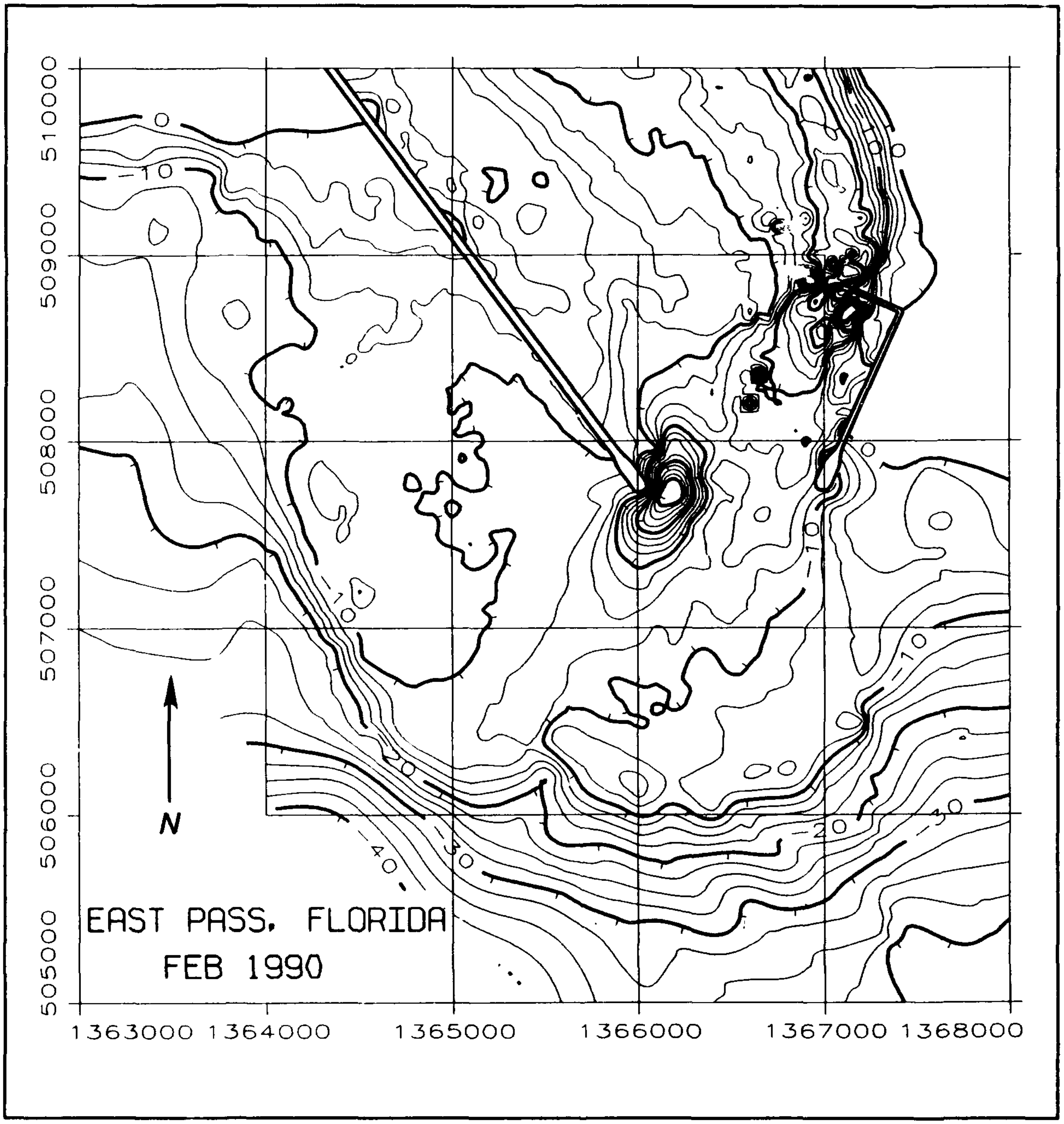

Figure 14. East Pass ebb-tidal shoal, February 1990. Depths in feet below MLW. Contour interval 2.5 ft. There are major scour holes at the west and east jetties

Changes in sand distribution over time are shown in Figure 15, which depicts the subtraction of the 1967 surface from the 1990 one. Green contours (1-ft interval) represent accumulation, and red (2-ft interval) are erosion. The wide green band shows where the shoal has grown seaward, with up to 24 ft of sand 1,700 ft south of the mouth of the inlet. The green immediately east of the east jetty marks the growth of the beach in the late 1960's. It has not been possible to determine what proportion of the deposition east of the east jetty was natural and what was man-made. (As a result, the seaward offset of the shore east of the inlet does not necessarily indicate anything about the predominant drift direction in this region during the last 20 years.) A broad area near the jetties (Polygon 2) has eroded, and over 38 ft has been lost from the scour hole at the west jetty. Within the inlet, the eastward movement of the channel is evident. When the weir was open, the area to the west of the west jetty in Polygon 17 was underwater about 5 ft. Since 1986, when the weir was closed, sand has accumulated here. The author confirmed that the beach had advanced seaward in this area during field visits in 1989 and 1990. No additional accumulation was seen during a field visit in March 1991, but based on this one observation, it is not possible to determine whether the beach has stabilized in this region.

To show the changes in the overall size and shape of the shoal over time, the 15-ft isobath has been plotted in Figure 12 for each of the seven gridded surveys. The contours have been smoothed for clarity. The figure shows that for the first few years after project construction, the shoal grew to the south in the form of a symmetrical semicircle, advancing as far as Polygon 8. After 1974, the bar front stabilized in 8, and further growth occurred in Polygons 4, 11, and 12 as the shoal bulged to the southwest.

To determine changes in the volume of the ebb-tidal shoal, the shoal was defined as the sand accumulation above -20 ft MLW within the 18 square polygons shown in Figure 12. The depth of 20 ft was chosen because this contour has consistently marked where the base of the steep bar front merges into the low-gradient Gulf of Mexico seafloor. When the combined volume of all 18 polygons is plotted against time (Figure 16), the curve reveals that between 1967 and 1990 the shoal's overall volume has increased only 19 percent, from 4,300,000 to 5,200,000 cu yd. Although this increase is less than the estimated error in the calculations, the trend is physically realistic because the shoal's area has increased. The fact that the curve is reasonably smooth suggests that the underlying data are good quality. If there had been major errors in the echosounder calibrations, tidal corrections, or cartography, it is likely that the curve would have displayed abrupt changes in volume. In addition, the smoothness of the curve indicates that the CPS3 software has not introduced any gross errors during its gridding or contouring procedures. Volumes for each of the 18 polygons are listed in Table 3.

When the ebb-tidal shoal was defined in a more restrictive manner, including only Polygons 4-9 and 11-13, the growth from 1967 to 1990 was over 600 percent, from 217,000 to 1,450,000 cu yd (Figure 16). This verifies that the seaward edge of the shoal has grown in volume, but does not take

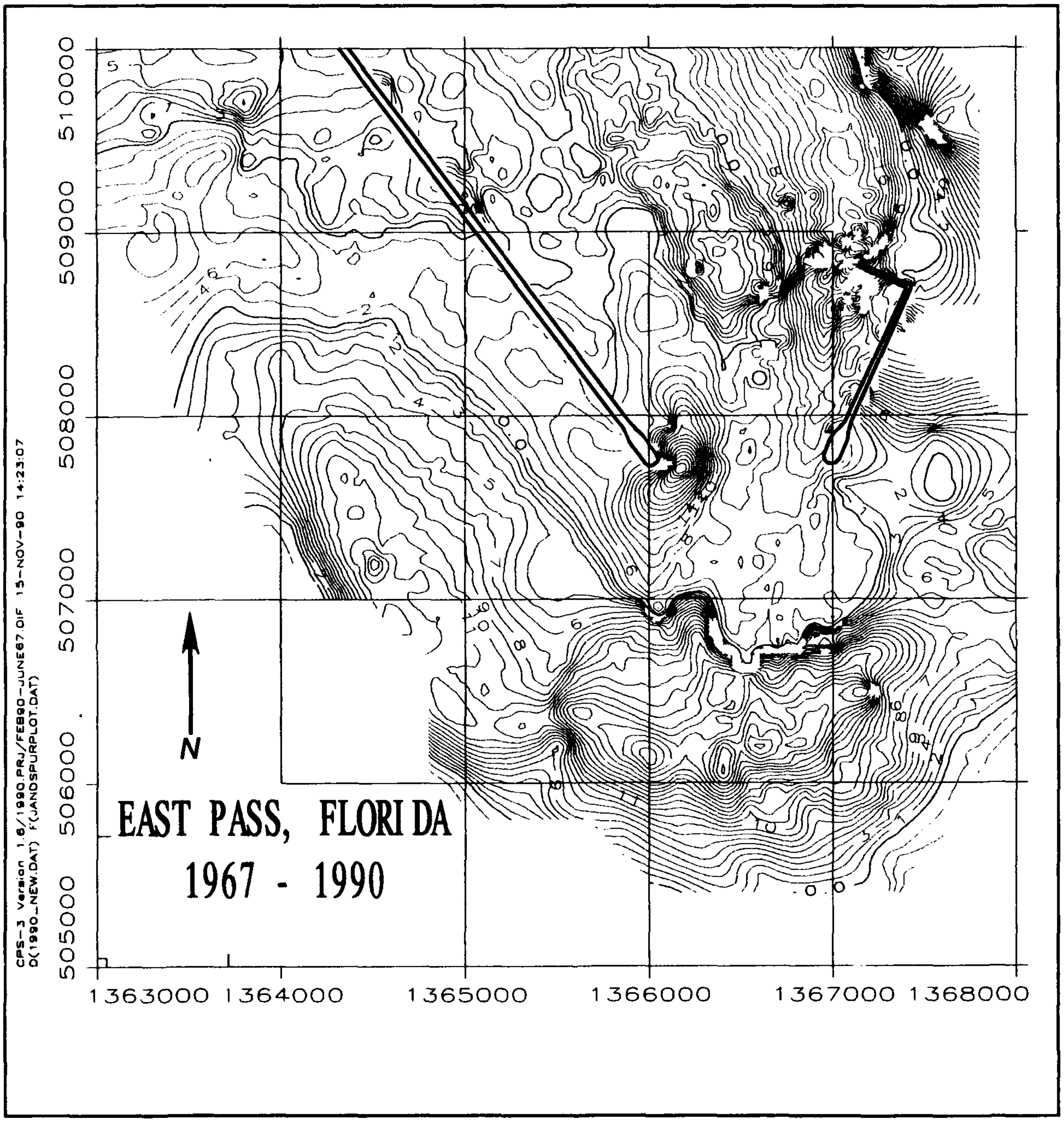

Figure 15. Isopach map showing amounts in feet of erosion and deposition at East Pass ebb-tidal shoal. Computed by subtracting June 1967 surface from February 1990 surface. Green contours (1-ft interval) represent deposition; red contours (2-ft interval) erosion

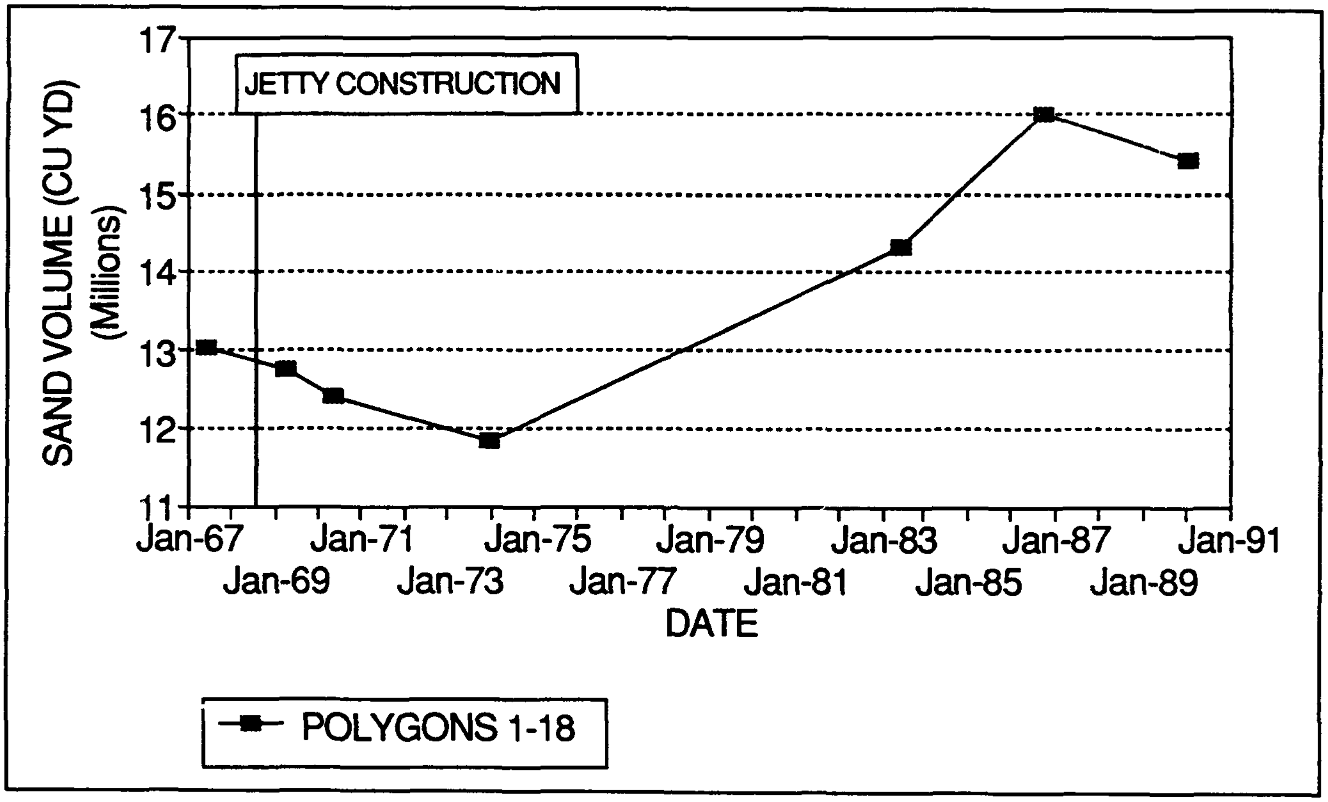

Figure 16. Ebb-tidal shoal growth from 1967 through 1990, East Pass, Destin. Locations of the polygons are shown in Figure 12

into account sand losses in the back bar area. It is clear from the discrepancy in the two growth values, 19 and 600 percent, that calculating "growth" of an ebb-tidal shoal is highly dependent on the boundaries of the region that are included in the analyses.

What do changes in the shoal's shape and volume indicate about longshore drift in this region? Over the past 23 years, the overall shoal (18-polygon area) has increased in volume by 810,000 cu yd, an average of about 35,000 cubic yards/year. This is less than the published estimates for annual net drift (Table 2). Actual drift is surely greater than the shoal's growth rate because it is unlikely that the shoal is trapping 100 percent of the sand in littoral transport. This conclusion is supported by the fact that the beaches to the east and west are not eroding. If the shoal were trapping all the littoral drift, one side or the other would be sand-starved and begin to erode. Because the proportion of drift that is bypassed cannot be estimated, it can be concluded only that net drift is greater that 35,000 cubic yards/year in the immediate vicinity of East Pass.

Why has the shoal's post-1974 growth been in the form of a bulge to the southwest? The simplest explanation is that the sand for this growth came from the west and that the net drift since 1974 has been from west to east.

Table 3
Ebb-Tidal Shoal Volumes

	Survey Date						
Polygon	Jun-67	Apr-69	May-70	Jan-74	Jul-83	Oct-86	Feb-90
Volumes in cubic feet [1]							
1	8701000	9253000	8878000	8540000	10760000	9631000	8015000
2	11540000	7560000	6957000	3713000	7250000	4799000	4735000
3	13803200	12950000	11818000	15711000	15274000	16886000	16437000
4	291900	721000	1790000	4719000	8730000	6926000	7996000
5	2950300	6323000	8153000	6559000	10848000	13356000	11460000
6	1060200	3687000	2374000	7074000	4891000	7504000	4860000
7	0	0	0	6700	186800	367000	229500
8	0	0	600	1589000	442300	1030000	714300
9	0	0	0	177700	700	11300	10800
10	10456700	9213000	8324000	7132000	9129000	8598000	7080000
11	2189	146600	0	1150	383000	1310000	3246000
12	1626000	2878000	1837000	1855000	5000000	7058000	9728000
13	276200	18000	174000	164000	69400	2301000	929600
14	7768000	5244000	5960000	4366000	3748000	6726000	5519000
15	11585000	11536000	10618000	7464000	11378000	11521000	11518000
16	16003000	16047000	14098000	10421000	16234000	14556000	13878000
17	16111000	14499000	15518000	13510000	14232000	1667000	17728000
18	15390000	14551000	15157000	13522000	10509000	14713000	14849000
SUM 1-18	1.17×10^8	1.15×10^8	1.12×10^8	1.07×10^8	1.29×10^8	1.44×10^8	1.39×10^8
Volumes in cubic yards							
SUM 1-18	4.34×10^6	4.25×10^6	4.14×10^6	3.95×10^6	4.78×10^6	5.33×10^6	5.15×10^6
Volumes in cubic yards (Polygons 4, 5, 6, 7, 8, 9, 11, 12, 13)							
	2.17×10^5	5.10×10^5	5.31×10^5	8.20×10^5	1.13×10^6	1.48×10^6	1.45×10^6

[1] Volumes in cubic feet above reference plane of -20 ft MLW. CPS3 software, CERC, June 1990.

Additional support is provided by the recent growth of the beach just west of the west jetty in the vicinity of the former weir.

It is too simplified to conclude that the drift is unidirectional. The historic uncertainty about the direction of the drift has been caused by conflicting geologic and physical evidence. If the circulation has a nodal point in this area that oscillates east and west, alternating eastward- and westward-flowing littoral currents could have supplied the sand trapped by the shoal. During field visits in 1989 and 1990, the author has seen morphologic evidence of drift in both directions. As stated earlier, the beach west of the former weir has grown, suggesting eastward drift. On the opposite side of the inlet, the beach has extended to near the seaward end of the east jetty for over 20 years. If the drift were uniformly to the east, erosion on this side would be expected. Therefore, it is reasonable to assume that west-flowing drift provides enough sand to maintain the beach east of the jetty. Nevertheless, an alternative mechanism may account for the relative stability of the beach east of the east jetty: the author has seen waves breaking on a shallow sandbar extending offshore in this region. Possibly the bar is part of the sand bypassing process described by FitzGerald (1988) whereby bar complexes move landwards across the ebb-tidal shoal and weld to the downdrift shoreline. Unfortunately, this hypothesis cannot be tested with the data collected during this MCCP project.

Because it is likely that the net longshore current has changed directions, a crucial question is how long does it flow to the east and to the west? Is the pattern oscillatory with a period of weeks or months? The directional wave data from the CERC gage at Fort Walton Beach show that short-term direction changes occur on a cycle of a few days. The growth of the shoal to the southwest since 1974 suggests that the drift has flowed predominantly to the east for at least 15 years, possibly indicating a cycle that occurs on a time scale of decades.

Has East Pass' ebb-tidal shoal reached a state of equilibrium or stability? Probably not. The bathymetric maps show that the shoal is in flux, and growth in a southwest direction since the 1970's has been clearly documented. Part of this growth occurred during the relatively mild wave conditions measured during 1987 to 1990 by the CERC wave gage. It is not possible to predict if such mild conditions will continue. Certainly if major storms pass nearby, rapid changes in the ebb-tidal shoal are likely to occur.

Tidal Hydraulic Data

General

Tidal hydraulic field studies were conducted at East Pass in October 1983, May 1984, and April 1987. Table 4 lists when data were collected:

Table 4
Tidal Current Measurements, East Pass, Florida

Year	Manual Current Meters	Internal-Recording Current Meters
1983	25 - 26 Oct	25 - 26 Oct
1984	15 - 16 May	15 - 16 May
1987	15 - 16 Apr	(none)

Manual current measurements were made from boats by personnel from USAED, Mobile, and CERC using Price AA current meters. The measurements were made hourly over 24-hr periods to record complete tidal cycles. The stations occupied were (a) East Pass, across the inlet south of the highway bridge; (b) East Pass, between the jetties; (c) Santa Rosa Sound at the Hwy 98 bridge in Fort Walton Beach; (d) mouth of Old Pass Lagoon; (e) weir (1983 and 1984); (f) flood-tide shoal West Channel near the Destin USCG Station; (g) flood-tide shoal North (also known as East) Channel, 2,000 ft north of Moreno Point. Water depths were measured across these channels with a Raytheon echosounder. By using the current velocities, tide elevations, and water depths, the volume of water flowing through the channels over time was calculated. The estimated error for the discharge calculations is ±25 percent. This error was primarily caused by ambiguities in determining the cross-sectional area of the channels. Arbitrary decisions had to be made on where to define the edges of the North and West Channels since they were flanked by subaqueous tidal flats.

Tide gages were established at various locations in East Pass and Choctawhatchee Bay. Table 5 lists the date and locations of tide data collection. The gages in the bay (Figure 2) were strip chart Stephens Leupold water-level recorders. The charts were digitized at CERC so that the tide curves could be plotted on uniform scales. At the Okaloosa County fishing pier in the Gulf of Mexico near Fort Walton Beach and the Rodeo Dock fishing pier in Destin, Sea Data internal-recording TDR gages were used. Surveyors from USAED, Mobile, surveyed the heights of the gages, and all tide curves were referenced to National Geodetic Vertical Datum (NGVD) North American Datum.[1]

Internal-recording Endeco 105 current meters (1983) and Endeco 174 meters (1984) were deployed near the jetties. The 1983 data were processed by Raytheon Service Company; the 1984 data by CERC.

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[1] Selected tide curves are presented in Volume II: 1983, Appendix F; 1984, Appendix G; 1987, Appendix H.

Table 5 Water Elevation Measurements, Choctawhatchee Bay, Florida			
Station	1983	1984	1987
Gulf of Mexico			25 Mar - 29 Apr
Destin (Old Pass Lagoon)	2 Sep - 28 Oct	16 Mar - 15 Jun	20 Mar - 7 May
Coast Guard Station	30 Sep - 27 Oct	18 May - 15 Jun	20 Mar - 7 May
Beacon 1, Intracoastal Waterway	19 Oct - 22 Nov	17 May - 16 Jun	25 Mar - 23 Apr
Fort Walton Bridge	19 Oct - 16 Nov	17 May - 17 Jun	27 Mar - 23 Apr
Beacon 4, Shalimar	30 Sep - 27 Oct	17 May - 21 May	26 Mar - 23 Apr
Beacon 49, Fourmile Point	30 Sep - 27 Oct	17 May - 17 Jun	26 Mar - 23 Apr
Beacon 46, Bascule Bridge	30 Sep - 21 Nov	17 May - 2 Jun	25 Mar - 23 Apr

Because so many data were collected during the three field experiments, it is not possible to display all of them in this report. Selected plots that are pertinent to important findings will be presented.

In order to measure long-term variations in flow through the inlet, two internal-recording Endeco 174 current meters were installed in February 1990 at a mooring north of the spur jetty along the east side of the inlet's thalweg. The meters were lost, and no data were recovered. Because this MCCP study was drawing to a close, there was neither time nor funds to repeat the current meter deployment. This accident is especially unfortunate because during February 1990, major flooding occurred throughout the watershed north of Choctawhatchee Bay. Destin's harbor master, Mr. Mitch Dudley, told the author that for several days so much runoff flowed out of East Pass there was essentially no incoming flood flow. It is likely that it was during this time that the spur jetty was damaged.

1983

The field work was conducted from 25-26 October 1983. During the afternoon of the 25th, high winds developed and the field crews had to abandon the North Channel because of hazardous conditions. Despite the difficult working conditions, data were collected at the other locations.

Currents were measured at four stations across the inlet south of the highway bridge (Figure 17). At each station, measurements were made at depths of 0.2, 0.5, and 0.8 times the total water depth. The near-surface (2 to 4 ft below the surface) data from sta 1-4 are presented in Figure 18.

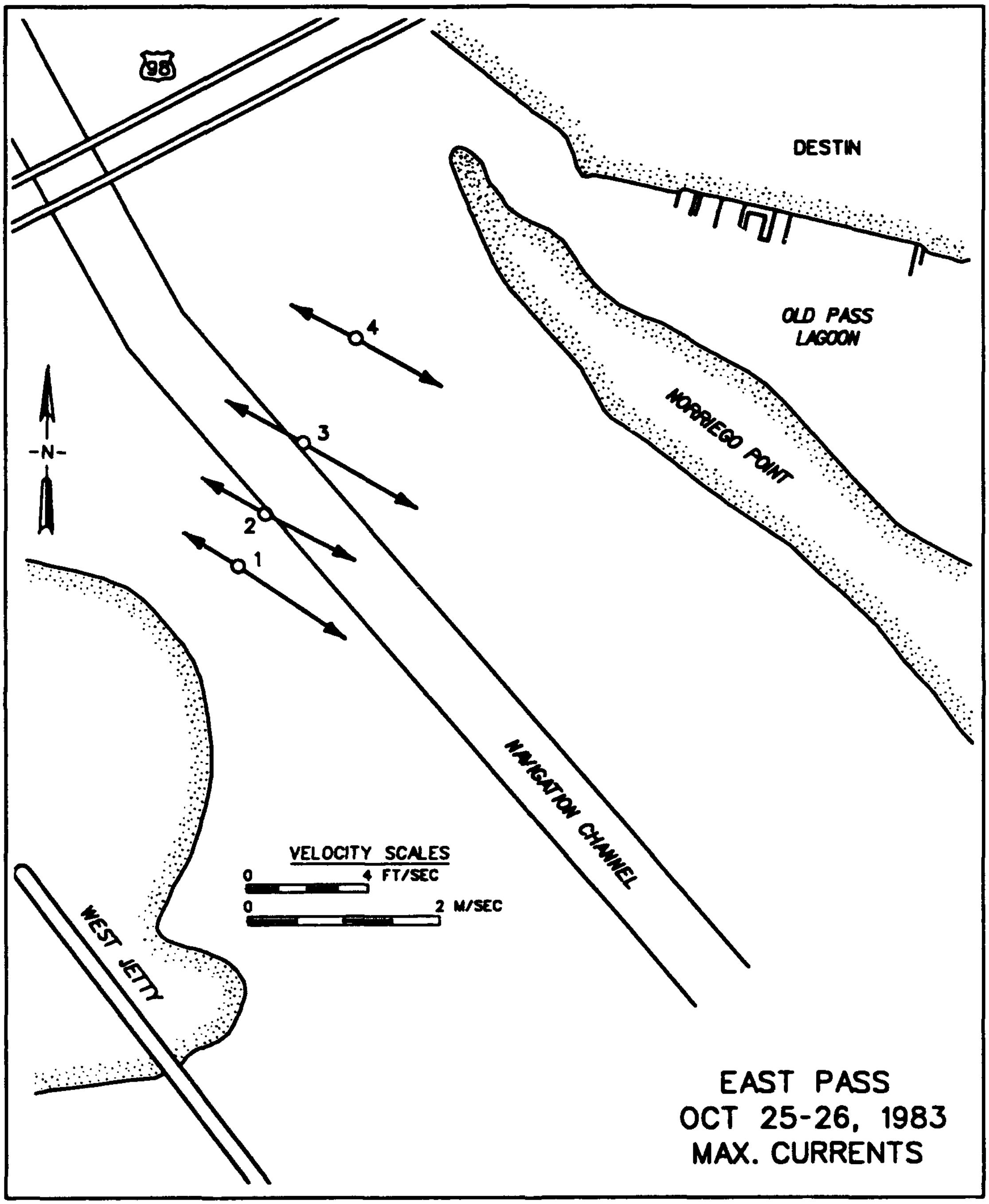

Figure 17. Maximum near-surface (2 to 4 ft below surface) currents (in feet per second) measured 25-26 October 1983 in East Pass at sta 1-4. Flood direction about 300 deg; ebb direction about 120 deg. Sta 1-4 were reoccupied during the 1984 and 1987 field studies

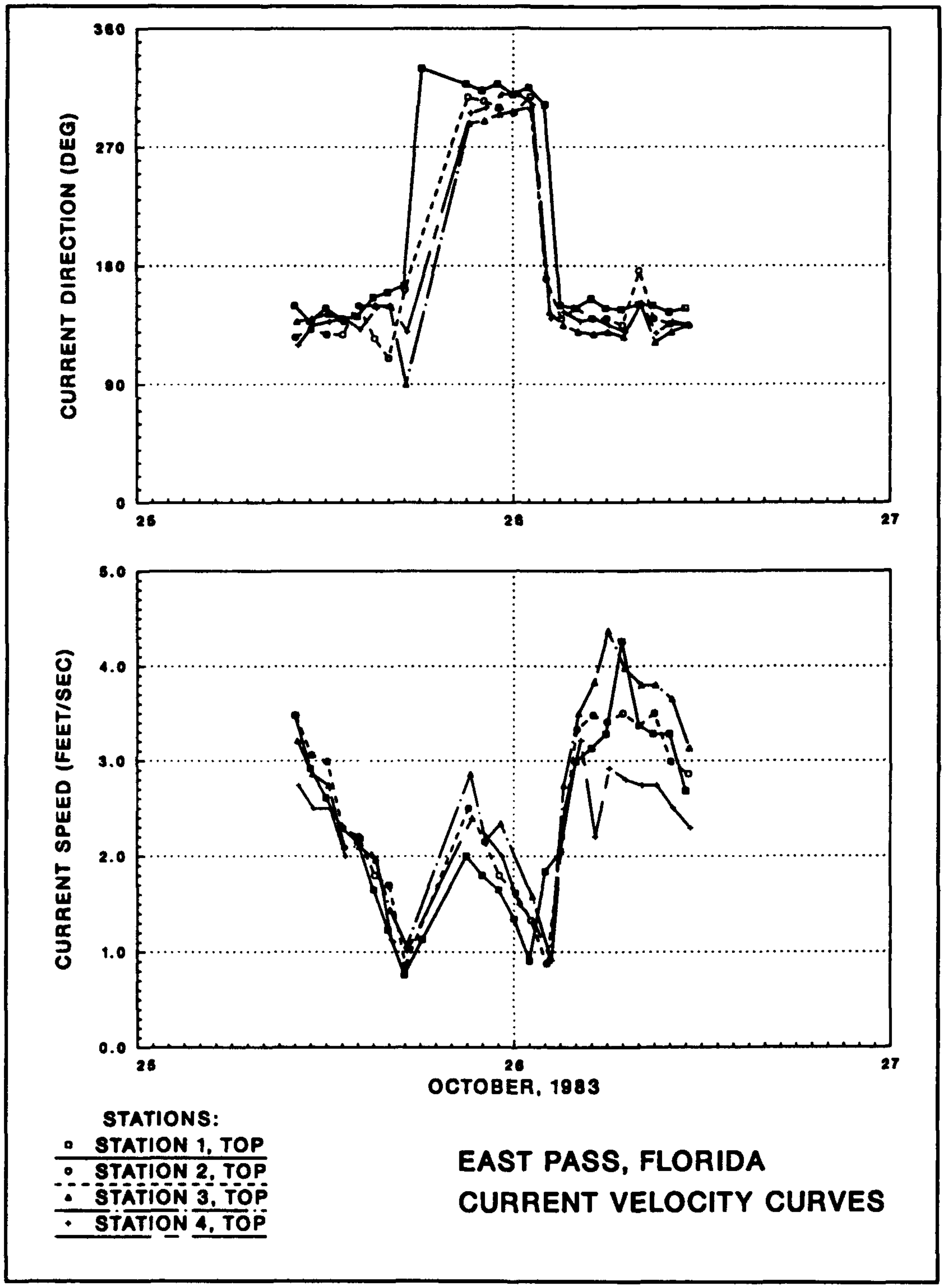

Figure 18. Near-surface current directions and velocities measured 25-26 October 1983 in East Pass at sta 1-4. In the upper plot, 300-deg currents are flood, while 120-deg currents are ebb

The upper plot shows the direction towards which the current is flowing, while the lower plot represents velocity in feet per second. These curves indicate that the currents change direction abruptly and that maximum ebb velocity (4.3 ft/sec) is higher than maximum flood (2.8 ft/sec). Middepth and bottom data are similar, except that velocities are lower.

The significance of these data are revealed when the current vectors are plotted on a plan view of this part of the inlet (Figure 17). The length of the arrows represents the maximum near-surface velocity. The 300-deg flood tide flows towards the bridge and the flood-tide shoal. The higher velocity 120-deg ebb flows towards the eastern shore on the inlet. This author believes that the ebb currents impinging on Norriego Point are responsible for the serious erosion there. The situation is analogous to the erosion that occurs to the outer side of a bend in a river. It is noteworthy that the orientation of Old Pass Lagoon is 115 and 295 deg, almost identical to that of the currents in this region.

The current data also reveal that currents may flow for a limited time in different directions when the tide is turning. An example is provided on Figure 19 by the measurements from 02:10 Central Standard Time (CST) on 26 October, as the tide was changing from flood to ebb. Flood currents continued to flow towards Choctawhatchee Bay along the west side of the inlet, while along the east side the water was flowing in the opposite direction. In the figure, the square symbol represents the surface (0.2) vector, the triangle the middepth (0.5), and the open circle the bottom (0.8). The arrows show that at sta 3 and 4, flow was to the southeast. At sta 2, the direction at each depth was different, suggesting a mixing zone. Finally, at sta 1, the surface and middepth flows were northwest, while the bottom was northeast.[1]

At the mouth of Old Pass Lagoon, the gages recorded currents of less than 1.2 ft/sec (Figure 20) flowing in opposite directions from top to bottom. Since Old Pass Lagoon is a small basin, the tidal range is small, and there is no other opening, water flowing into the lagoon at one depth is balanced with an approximately equal amount flowing in the opposite direction at another depth. The middle current sensor was positioned in the shear zone and recorded frequent direction changes. Similar slow currents were measured in the mouth of Old Pass in 1984 and 1987, suggesting that velocities less than 1.0 ft/sec are typical here. The slow currents help explain why much sediment has been deposited in this area.

To determine discharge, or volume of water flow through East Pass, the instantaneous average velocity, V, was multiplied by the cross-sectional area, A_c. V was calculated by averaging the 12 measurements from sta 1-4. A_c, which varied from hour to hour depending on the stage of the tide, was calculated using the echosounder records and the tide heights from the Destin

[1] Additional plots of 1983 current measurements are presented in Volume II, Appendix I.

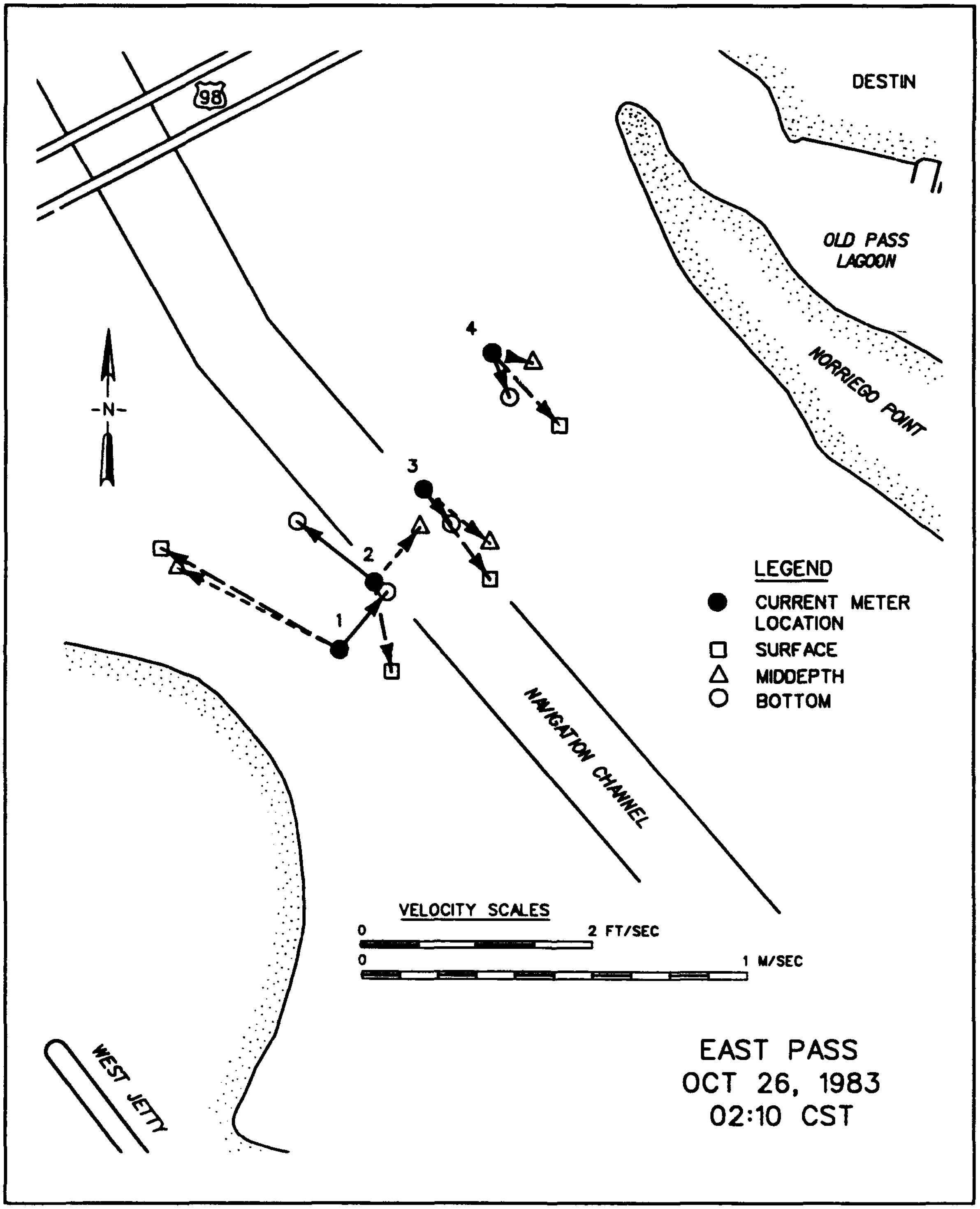

Figure 19. Currents measured at 02:10 CST on 26 October 1983 in East Pass at sta 1-4

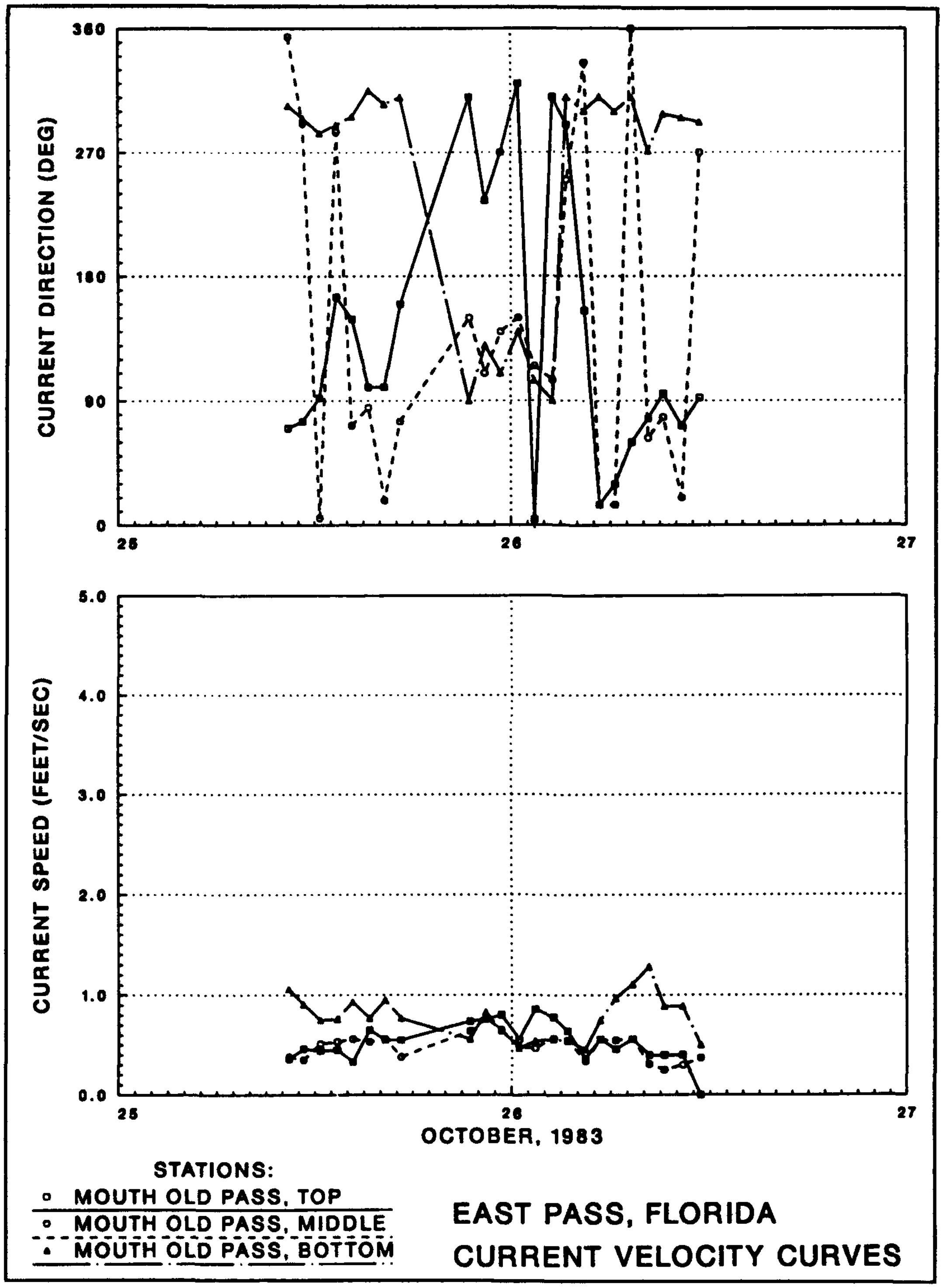

Figure 20. Currents measured in the mouth of Old Pass Lagoon 25-26 October 1983

tide station. Similar calculations were made for Santa Rosa Sound and the North and West Channels. The resulting discharge curves are plotted in Figure 21 in units of cubic feet per second. The upper half of the plot represents flood flow into Choctawhatchee Bay, while the lower half is ebb flow out of the bay.

Maximum flood flow through East Pass (square symbol) was 60,000 cu ft/sec. During the ebb, discharge was over 70,000 cu ft/sec for 8 hr. The curve for the North Channel (circular symbol) is short because the measurements were discontinued during high winds. The flow at Fort Walton Beach (+ symbol) was much less than that through East Pass, and the phase was different. With the available data, it was not possible to determine how much of the water flowing through Santa Rosa Sound came from Pensacola Bay 45 miles to the west.

Selected tide curves from Destin and Choctawhatchee Bay are shown in Figure 22. Unfortunately, tide data from the Gulf of Mexico are not available for this time. Within Choctawhatchee Bay, the overall tide range was less than 1.0 ft. The range and phase varied among the stations in the bay. The average bay water level varied during the month by up to 0.8 ft. These changes may be caused by meteorological forcing. Further study is needed to identify and quantify the effects of wind and atmospheric pressure changes on water levels in Choctawhatchee Bay and the nearshore Gulf of Mexico.

1984

Because the 1983 field work was partly disrupted by rough weather, the program was repeated during 15-16 May 1984. Similar field equipment and procedures were employed.

At sta 1-4 across East Pass, higher velocities were recorded in 1984 than during the previous experiment (Figure 23). As expected, velocity was higher near the surface than near the bottom, with a difference of up to 1.5 ft/sec at Sta 3 and 4 (Figure 24).[1]

The high current velocities resulted in high discharge (Figure 25). During the ebb, the flow was between 90,000 and 100,000 cu ft/sec for over 8 hr, and a similar rate occurred for 2 hr during the flood. As in 1983, the ebb was longer in duration than the flood.

The flow of water around and over the broad, shallow flood-tide shoal may be responsible for the orientation of the currents within the inlet. The flow through the North Channel (circular symbol) was about four times that through the West Channel (triangular symbol). Since the North Channel trends approximately north-south and the flow through the West Channel is

[1] Additional plots of 1984 current measurements are presented in Volume II, Appendix J.

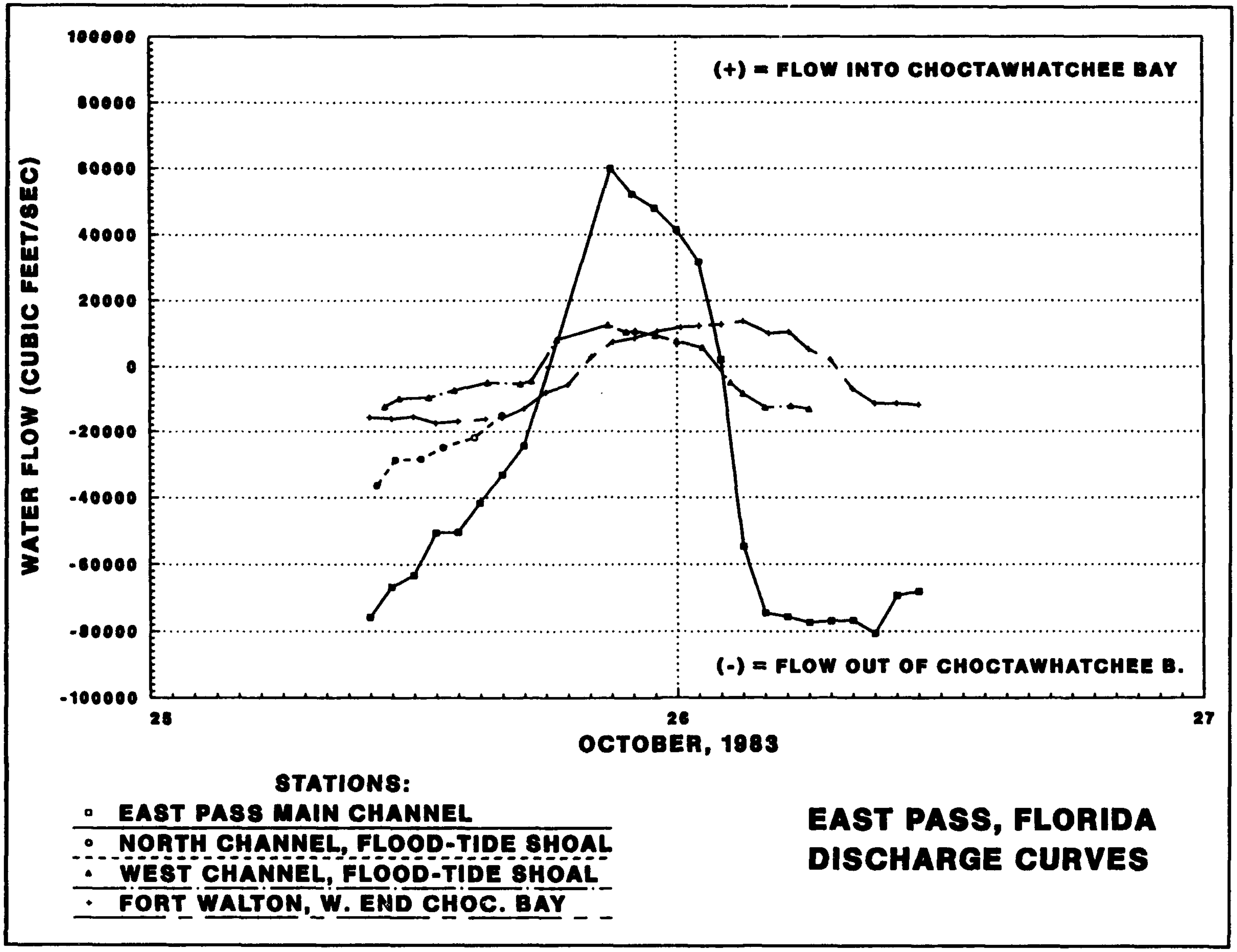

Figure 21. Discharge hydrograph based on data collected 25-26 October 1983 in East Pass and Choctawhatchee Bay. Error estimated to be +/- 25 percent

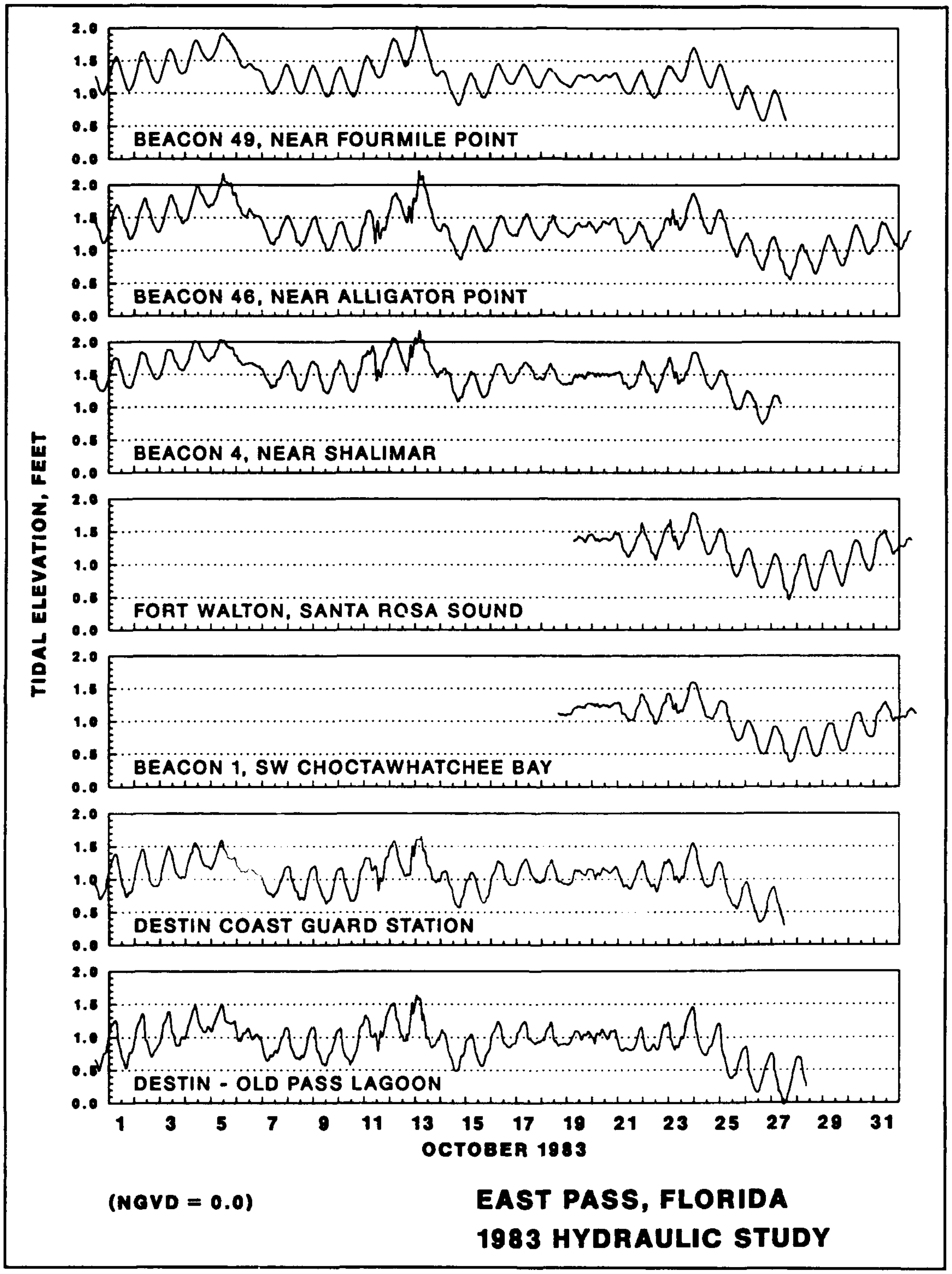

Figure 22. Tide curves from Choctawhatchee Bay and Old Pass Lagoon. Locations of tide stations are shown in Figure 2.

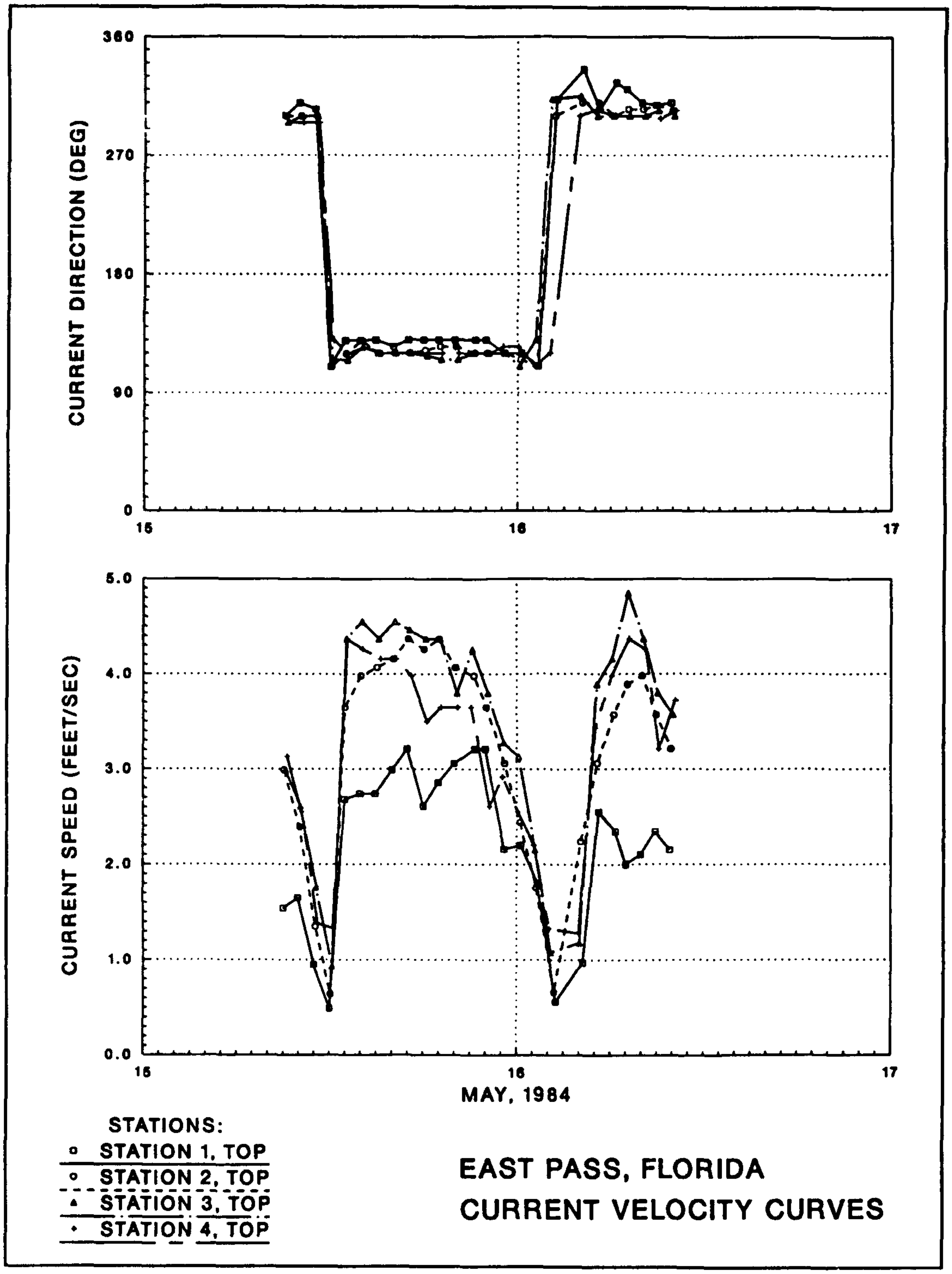

Figure 23. Near-surface current directions and velocities measured 15-16 May 1984 in East Pass at sta 1-4. Velocities were generally higher than those measured in 1983

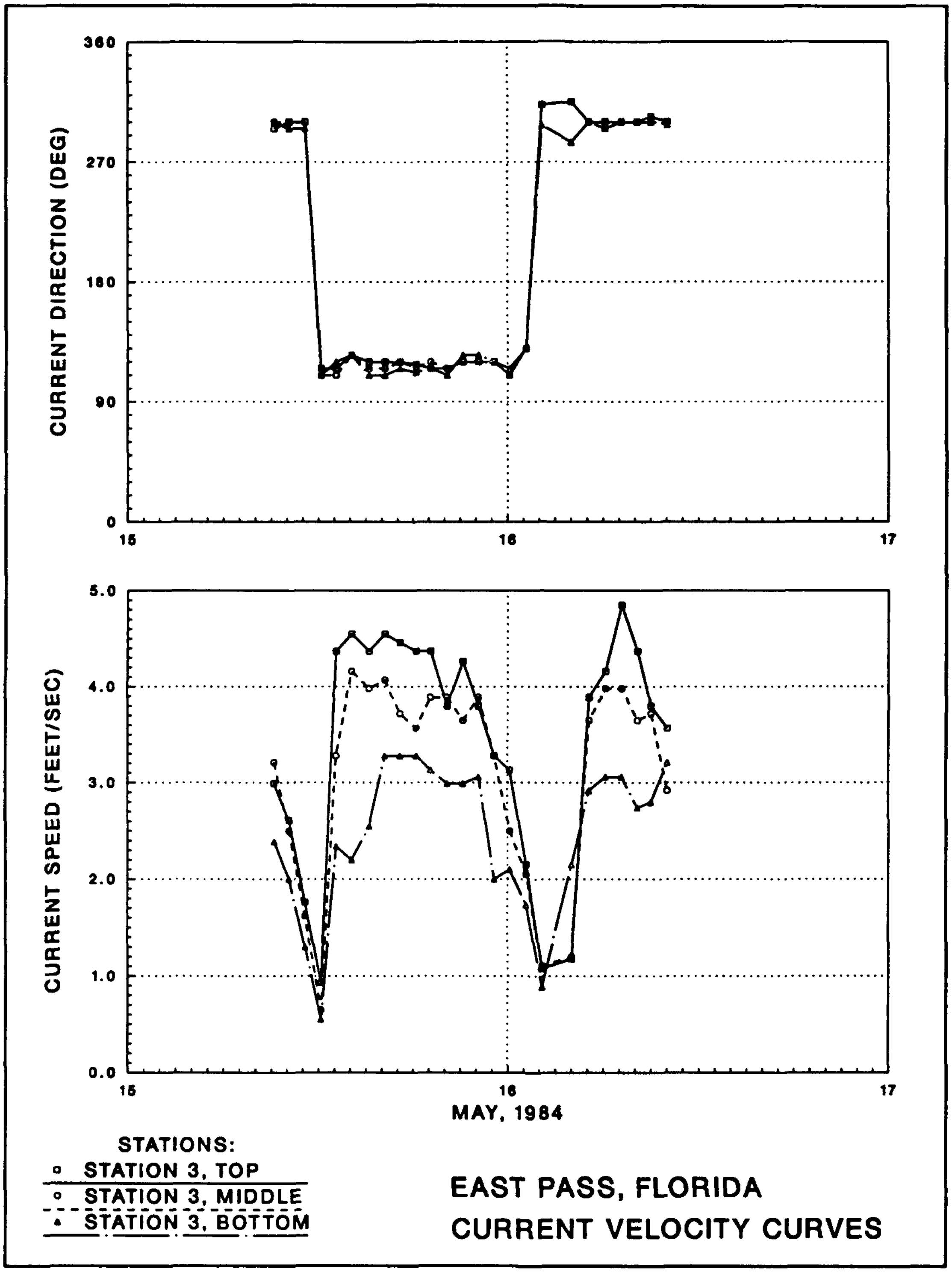

Figure 24. Near-surface, middepth, and bottom currents measured 15-16 May 1984 in East Pass at sta 3

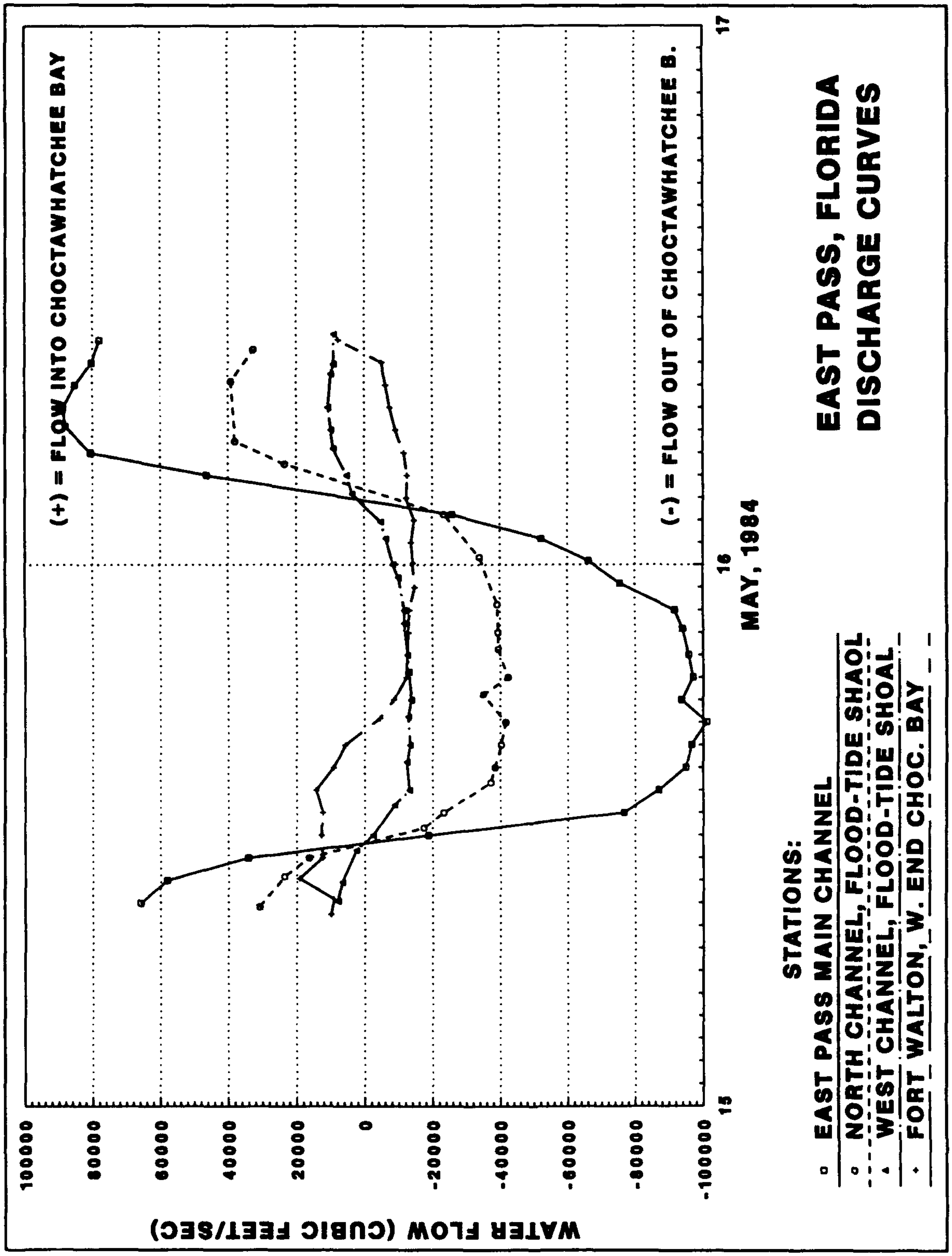

Figure 25. Discharge hydrograph based on data collected 15-16 May 1984 in East Pass and Choctawhatchee Bay

much less, it is surprising that the currents south of the bridge have such a strong east-west component (120 and 300 deg, as shown in Figure 17). This orientation indicates that the currents are diverted by a large amount of water flowing over the flood-tide shoal. The combined flow from the North and West Channels accounts for only about 50 percent of the discharge through the main East Pass Channel. Therefore, the rest must flow through minor channels and over the tidal flats. In summary, during the ebb tide, water from the shoal flows towards the bridge in a southeast direction. During the flood, water flows under the bridge in a northwest direction. About 50 percent of this water moves through the North and West Channels, while the rest proceeds over the flood-tide shoal.

The flood-tide shoal has probably had a major influence on directing the flow of water through East Pass since before 1871. The pre-1928 East Pass had a northwest-southeast orientation, and the currents in the northern part of the present inlet still flow in these directions. Historic aerial photographs of the East Pass area show that the flood-tide shoal has not changed much in overall size or shape since the 1920's.

One of the original purposes of this monitoring project was to determine the hydraulic effects of the weir. The amount of water flowing over the weir was negligible compared with that flowing through the inlet at sta 1-4 (Figure 26). The weir's flow was so much less than the estimated error of 25 percent (about 20,000 cu ft/sec) for the inlet flow calculations that hydraulic effects caused by the weir cannot be detected.

1987

The 1987 current measurements were made on April 15 and 16.[1] The results, shown on Figure 27, are similar to those from the previous field experiments. As in 1984, the combined flow through the North and West Channels accounted for only about 50 percent of the water flowing through the main channel.

Tidal elevations measured at the Okaloosa County fishing pier in the Gulf of Mexico and at Beacon 4, near Shalimar, are shown on Figure 28. From 30 March to 1 April, the gulf water level dropped about 2.0 ft, accompanied by a 1.3-ft drop at sta 4. It is noteworthy that although the gulf tide rose during the early hours of the 31st, the bay continued to drop steadily. This indicates that the ebb flow through East Pass was of such magnitude that it completely overwhelmed the incoming flood tide. Preliminary analyses indicate that these changes in water level can be directly correlated with the passage of a winter cold front. The northwest winds that follow the front cause nearshore Gulf of Mexico waters to drop, leaving Choctawhatchee Bay perched at a higher level. An example is shown in Figure 4. Captured

[1] Plots of selected 1987 current measurements are presented in Volume II, Appendix K.

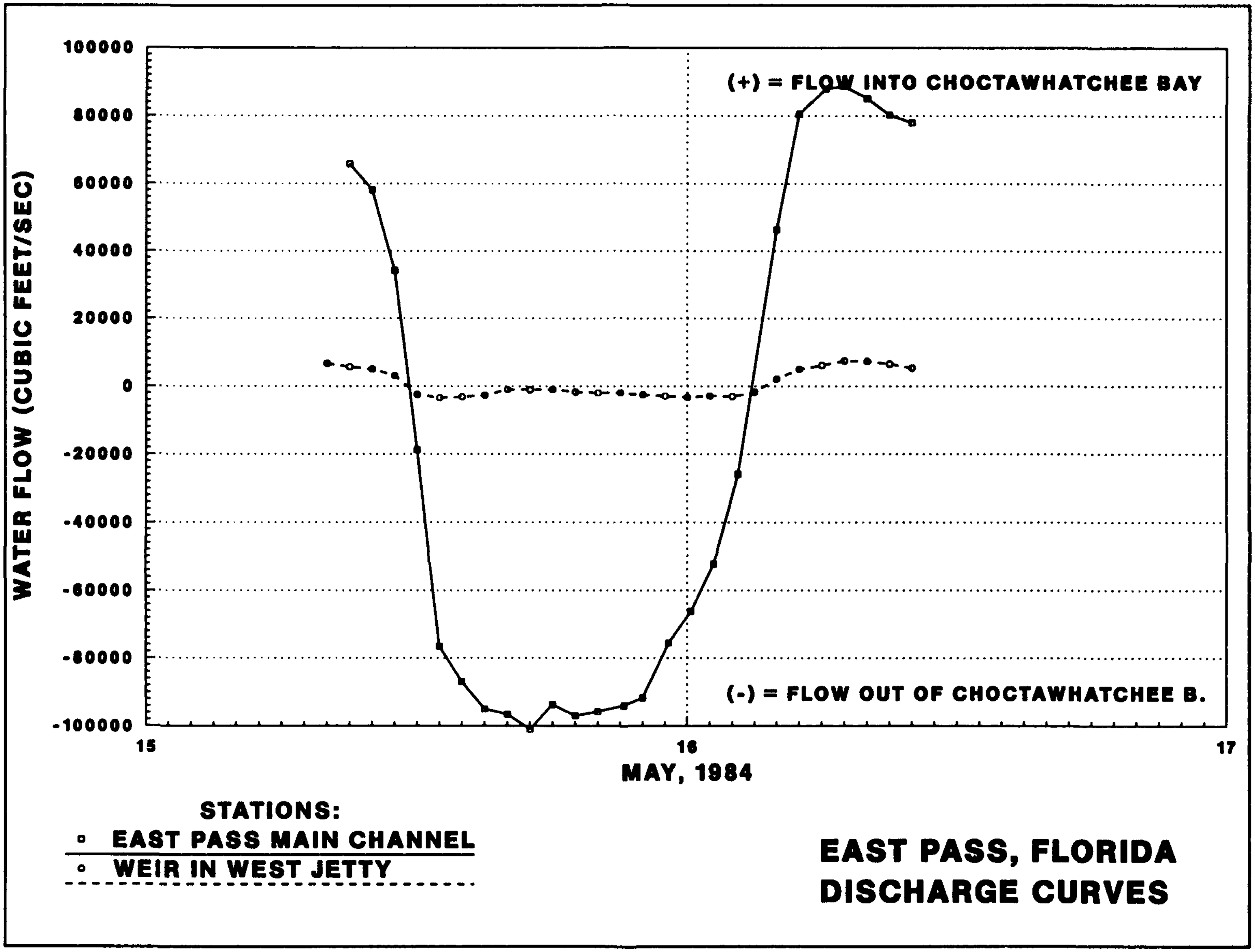

Figure 26. Comparison of water flow over weir in west jetty with flow through main East Pass Channel at sta 1-4, 15-16 May 1984

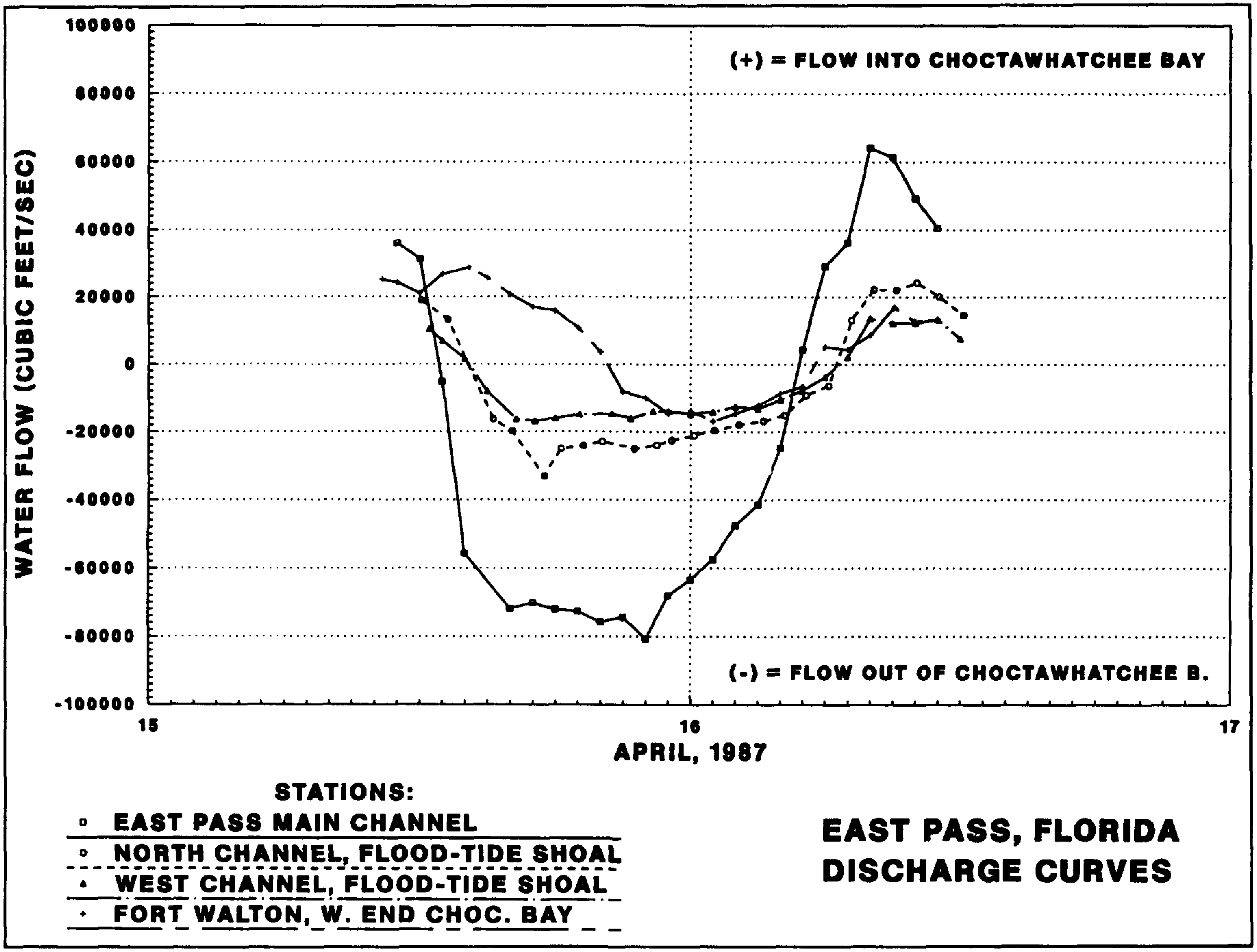

Figure 27. Discharge hydrograph based on data collected 15-16 April 1987 in East Pass and Choctawhatchee Bay

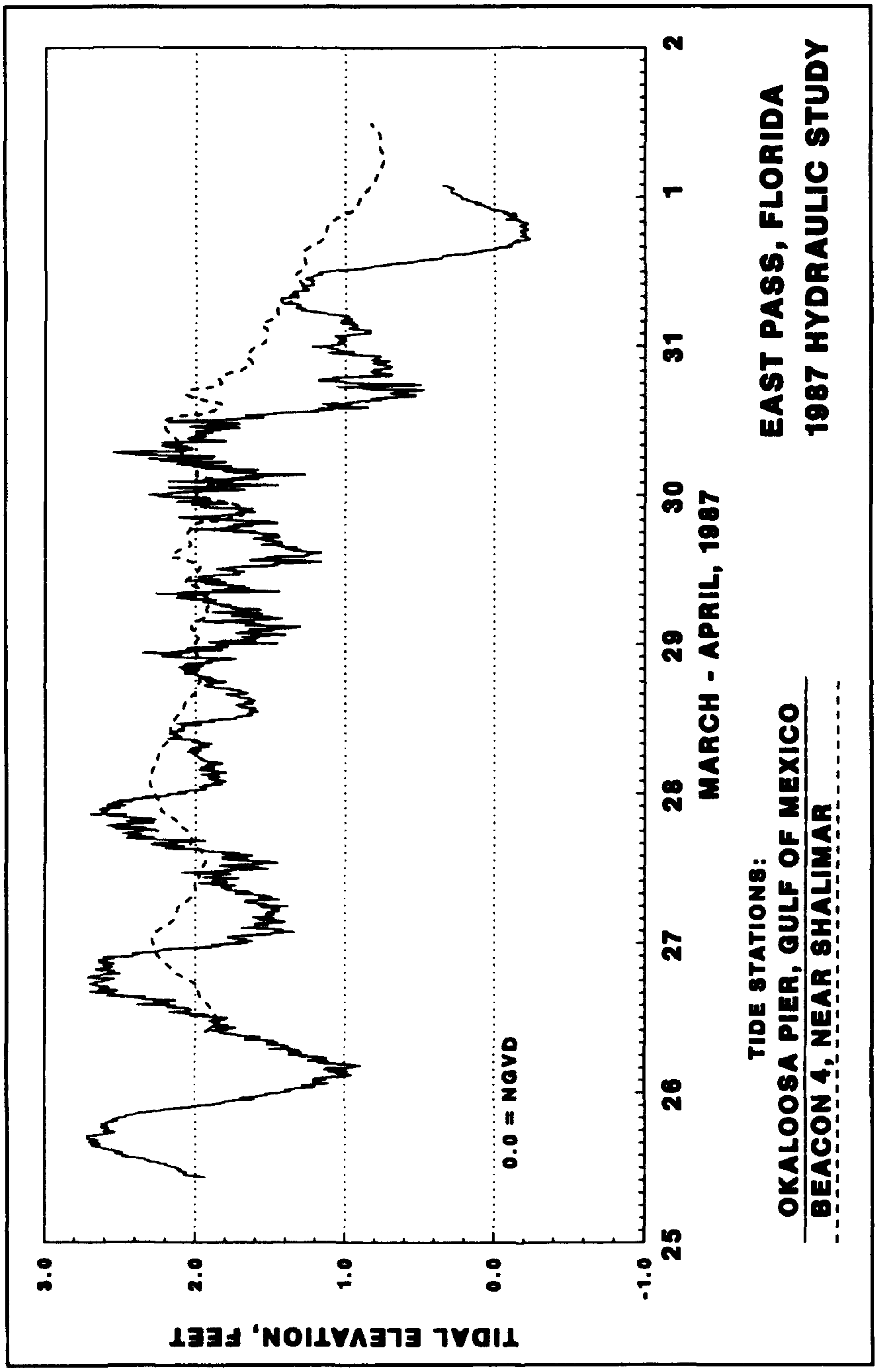

Figure 28. Tidal elevations measured in the Gulf of Mexico and in Choctawhatchee Bay

2 days after the passage of a front, the image shows a plume of cold water (pale green color) flowing out of Choctawhatchee Bay. This phenomenon was previously noted in US Congress (1928), although no data were presented. Further investigation is needed to examine the effects of meteorological forcing of Choctawhatchee Bay water levels and the interaction with gulf water levels and freshwater runoff.

1938

East Pass and Santa Rosa Sound discharge hydrographs for 20-21 April 1938 (US Engineer Office, Mobile 1939, Plate 12) were digitized and replotted in Figure 29. In 1938, the maximum flood and ebb flows through East Pass were about 50,000 cu ft/sec. Although these values are less than the ones based on the 1980's field studies, the measurement and computing procedures used in 1938 are unknown. Consequently, it is not possible to determine if the 1938 values are statistically different from the 1980's ones. It appears that there have not been gross changes in flow through East Pass since the 1930's.

Summary

Approximate maximum current speeds are shown in Table 6:

Table 6
Maximum Currents in Feet per Second Measured at East Pass in 1983, 1984, and 1987

Location	Flood (into Choctawhatchee Bay)		Ebb (out of Choctawhatchee Bay)	
	Surface	Bottom	Surface	Bottom
Sta 1-4, EP	4.5 - 5.0	2.5 - 3.0	4.5 - 5.0	3.0 - 3.5
North Channel	2.5 - 3.0	2.0 - 2.5	3.0 - 3.5	2.5 - 3.0
West Channel	1.5 - 2.0	1.5 - 2.0	2.0 - 2.5	1.5 - 2.0
Fort Walton	1.5 - 2.0	1.0 - 1.5	1.5 - 2.0	1.0 - 1.5

Note: Mouth Old Pass Lagoon: 0.5-1.5 ft/sec throughout the day.

Along sta 1 - 4 across East Pass south of the Hwy 98 bridge, ebb currents flow towards 120 deg and flood currents towards 300 deg. This is about the same orientation as Old Pass Lagoon, the pre-1928 inlet.

Near sta 3 and 4, the ebb currents are directed towards the east shoreline of the inlet. This has caused the serious erosion along Norriego Point sand spit.

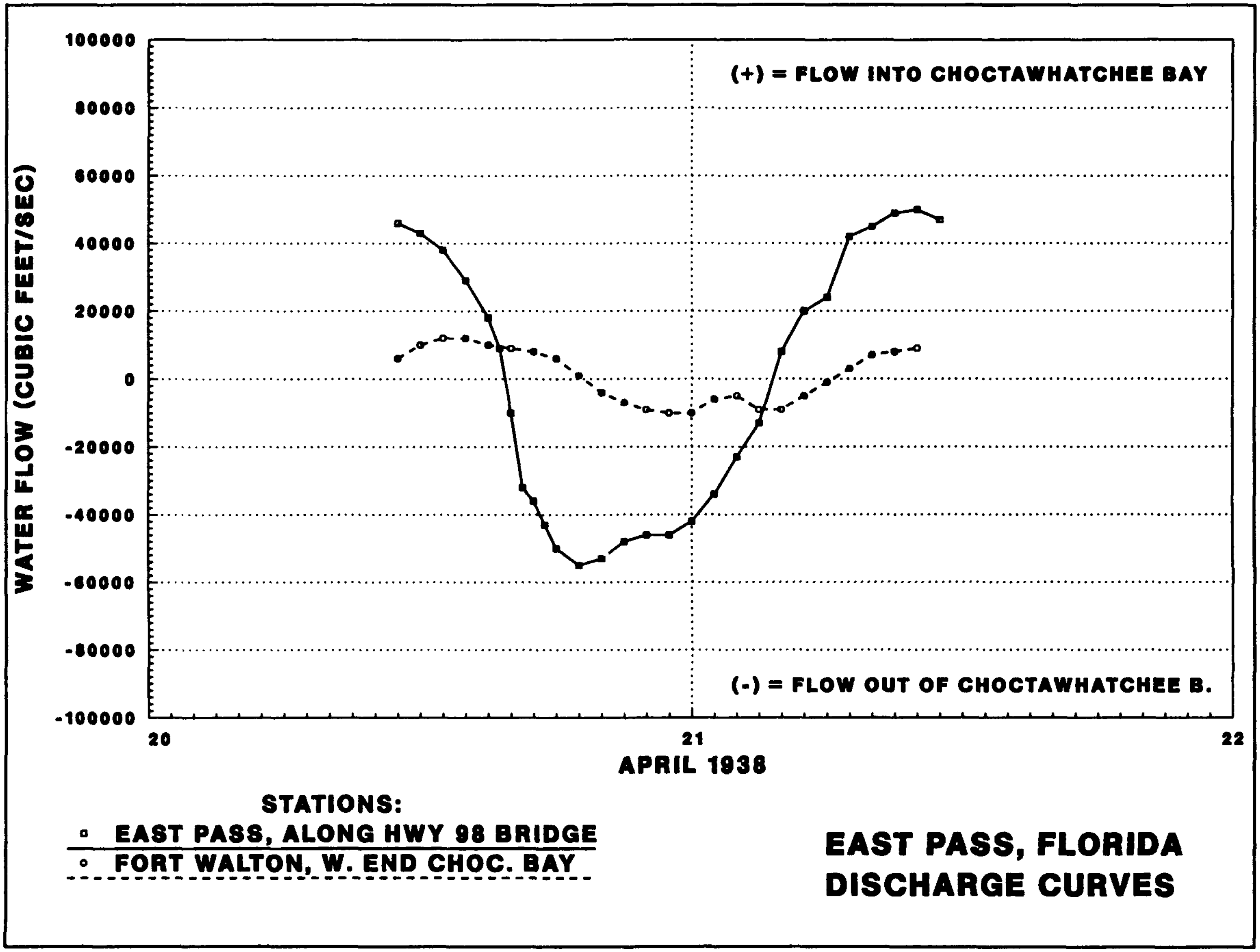

Figure 29. Discharge hydrograph based on data collected 20-21 April 1938 in East Pass and Choctawhatchee Bay. Curves have been digitized and replotted from Plate 12, US Engineer Office, Mobile (1939). Estimated error of these calculations is unknown

North of the Hwy 98 bridge, about 40 percent of the inlet's water flows through the North Channel, about 10 percent through the West Channel, and the rest over the flood-tide shoal. The water from the shoal and the West Channel direct the ebb currents towards the southeast in the vicinity of the bridge.

The amount of water flowing over the weir was negligible compared with the quantity flowing through the main East Pass Inlet. It seems improbable that the weir had any significant hydraulic effects on the currents in East Pass.

There do not appear to have been major changes in discharge through East Pass since the 1930's.

Sediment Grain Size

Surface sediment samples were taken in 1989 within East Pass and from the flood-tide and ebb-tide shoals. The samples were washed, dried, and sieved at CERC. The results are presented in Figures 30, 31, and 32 in the form of weight percent plots. Above each curve is plotted the mean grain size of the sample along with a bar representing ± 1.0 standard deviation (SD). The results are summarized as follows:

a. Within 1.0 SD, all the samples were the same size, ranging from about 1.0 to 2.0 phi (0.25 to 0.5 mm).

b. The dry land samples (Nos. 1 and 2, Figure 30, and No. 1, Figure 32), with a mean size of about 1.8 phi (0.29 mm), were slightly finer than the underwater samples. Possibly this reflects the presence of wind-blown sand. A significant amount of sand may be brought to East Pass by west winds blowing over the sand dunes of Santa Rosa Island. The present data do not allow testing this hypothesis.

c. The samples from the ebb-tidal shoal had a mean size of about 1.3 phi (0.41 mm). One sample from a 20-ft depth at the base of the shoal's bar front was bimodal, with peaks at 1.0 phi (0.5 mm) and 1.8 phi (0.29 mm). The fine component may be brought by the ebb tide from Choctawhatchee Bay. As the ebb jet expands over the shoal, it slows and drops its sediment load. Over the shoal itself, wave action keeps the finer sediments in motion, but some settle in deeper water at the base of the bar front. This hypothesis is supported by aerial photographs that show black streaks extending radially from the inlet's mouth over the shoal and black patches seaward of the bar. The black material may be humate-stained sands from the shores of Choctawhatchee Bay (Swanson and Palacas 1965).

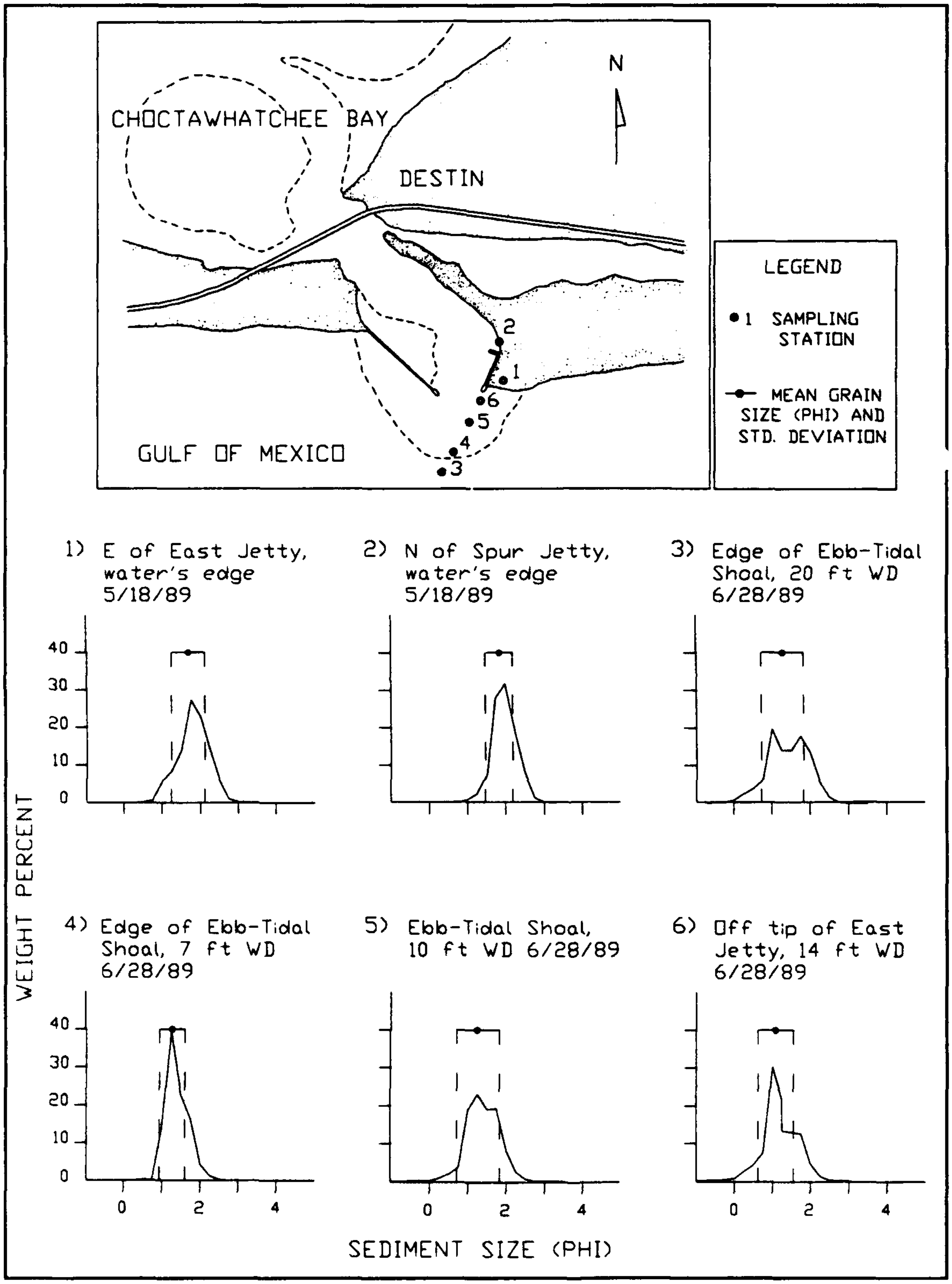

Figure 30. Sediment grain-size analyses, East Pass ebb-tide shoal

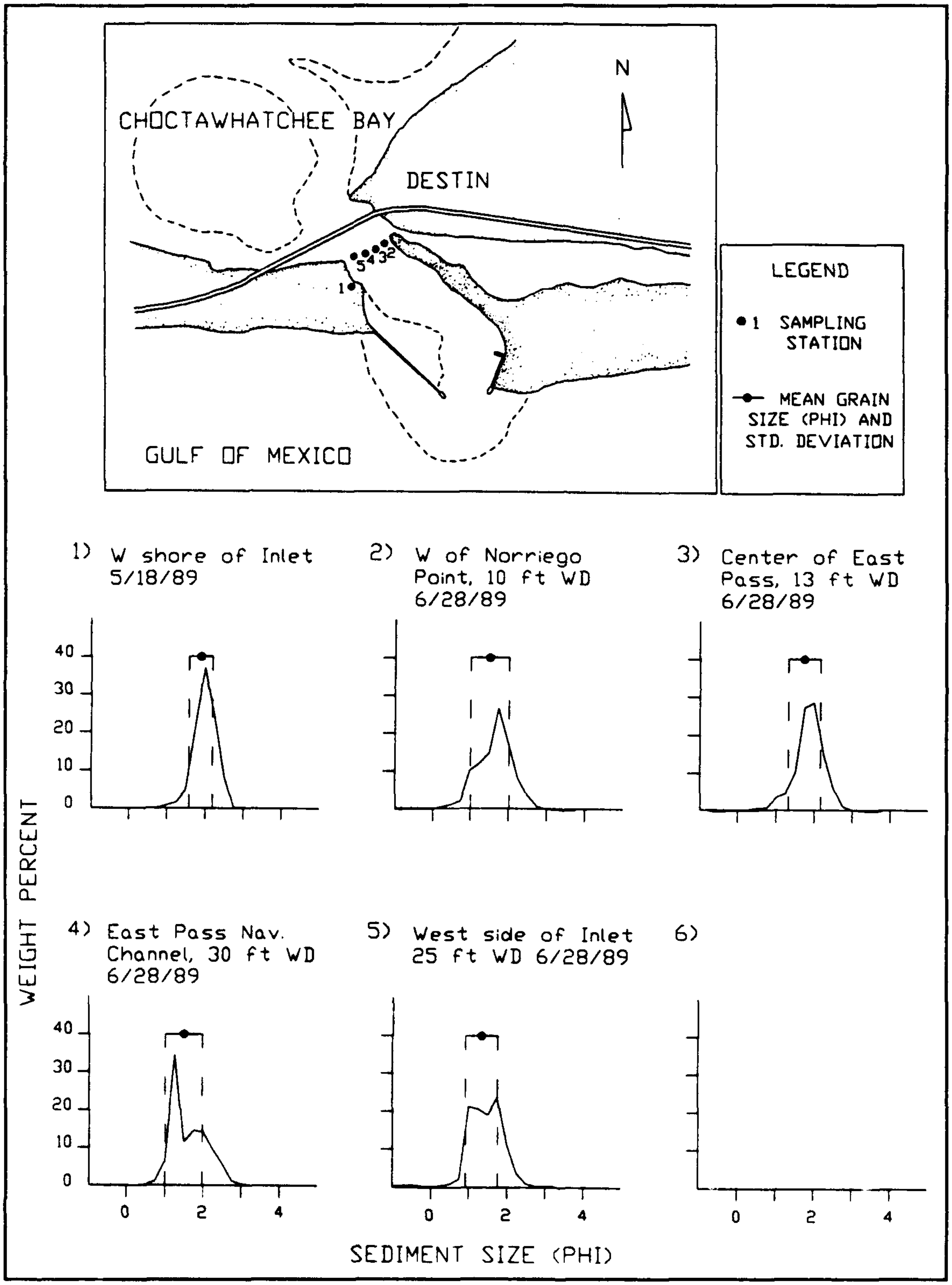

Figure 31. Sediment grain-size analyses, East Pass Channel

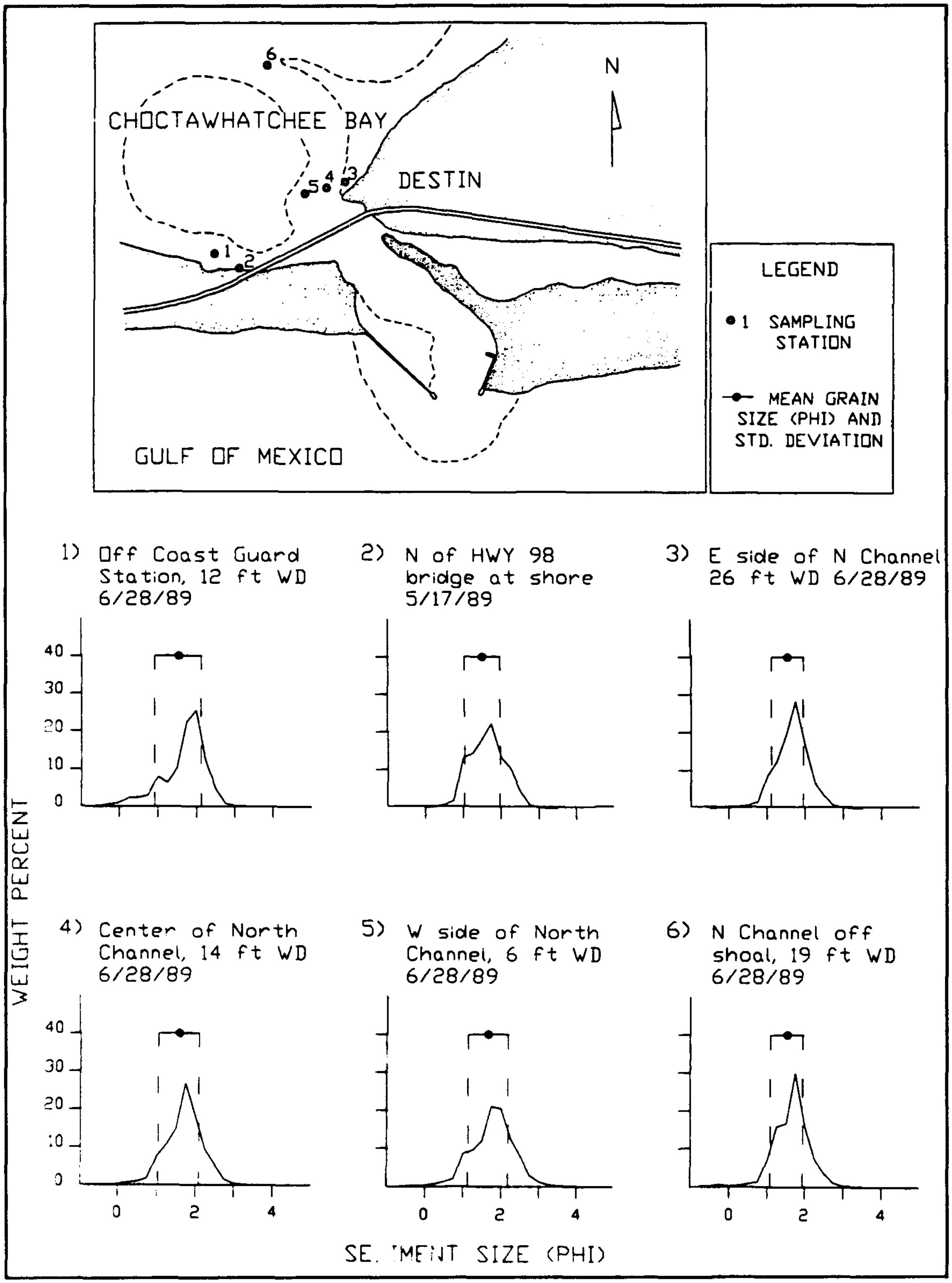

Figure 32. Sediment grain-size analyses, East Pass flood-tide shoal

d. The underwater samples from within the inlet and from the flood-tide shoal had a mean size of about 1.5 phi (0.35 mm). The similarity in size and color of these sands to the ones sampled at the ebb-tidal shoal suggests that their source was the Gulf of Mexico side of the inlet and not Choctawhatchee Bay. Sands sampled in the southwest part of Choctawhatchee Bay by Goldsmith (1966) were well rounded, had a yellowish color, and were typically smaller than 1.7 phi (0.31 mm).

In summary, sediments in East Pass and on the flood-tide shoal resemble the sands found on the ebb-tidal shoal. Some finer grained sediments are flushed out of Choctawhatchee Bay with the ebb tide, but the quantities appear to be small.

Shoreline Changes 1965 - 1990

With the construction of the jetties in the late-1960's, the Gulf of Mexico entrance to East Pass was fixed. Prejetty shoreline changes in and near East Past are shown in Figures 5 and 6. Despite the stability provided by the jetties, the June 1976, October 1986, and February 1990 shorelines illustrate that changes have continued (Figure 33). The shores, digitized from hydrographic maps prepared by the Panama City Area Office, represent 0.0 ft MLW. The original maps were drawn from field survey data.

Along Norriego Point sand spit, the four curves do not show the full extent of the erosion over the last 25 years because the spit has been renourished many times. Without this repair work, the spit would have either disappeared or moved northeast into Old Pass Lagoon as the inlet's thalweg migrated eastward. During the last 50 years, the tip of Norriego Point has periodically blocked the entrance to Old Pass Lagoon, requiring emergency dredging to clear the navigation channel.

On the west side of the inlet, sand has accumulated on the eastern end of Santa Rosa Island. In May 1965, the island ended at a pointed tip near the present northern end of the west jetty. A low island to the north was used as a deposition area during dredging operations. Large sand dikes were built in 1967 and 1968 to anchor the landward end of the west jetty. The vegetated sand dunes now found in this area are remnants of the dikes, and the channel separating Santa Rosa Island from the dredge disposal island has become a brackish pond. Once the weir was closed in 1986, the shore on both sides of the jetty advanced seaward. By February 1990, the beach on the west side of the west jetty had advanced about 1,000 ft, as far as the former southern end of the weir. It seems likely that the sand that has nourished this growth has been carried by eastward-moving longshore currents.

During construction, sand was deposited east of the east jetty. By the time the project was finished, the beach extended almost to the tip of the jetty. It

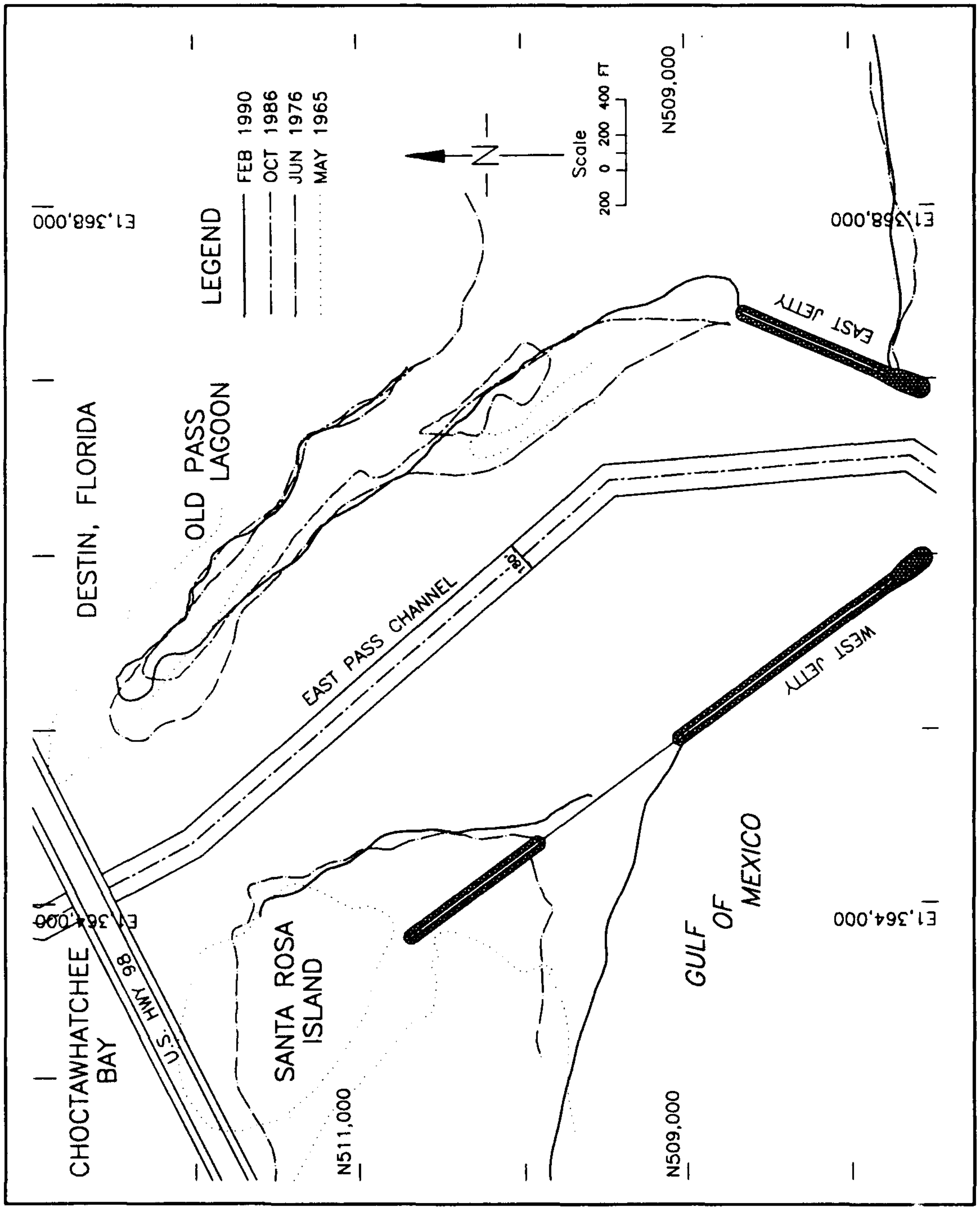

Figure 33. Shoreline changes, 1965-1990

is not possible to determine how much of this beach growth was man-made and how much was the result of the new jetty impounding west-flowing drift.

In summary, Norriego Point has suffered erosion for the past 25 years, and all evidence suggests that this trend will continue. With the closure of the weir, the shore of Santa Rosa Island has advanced seaward about 1,000 ft. The shore east of the east jetty has been stable since 1969.

5 Dredging in East Pass, 1931-Present

Historic Dredging Data

Curves of the cumulative amount of sand dredged at East Pass are plotted against time in Figure 34. These data have been culled from the Annual Reports of the Chief of Engineers on Civil Works Activities and from statistics compiled by personnel at Mobile District. The data and explanatory notes are detailed in Table 1.

Dredging statistics are available for two projects: the main 12- by 180-ft East Pass Channel from the Gulf of Mexico to Choctawhatchee Bay and the shorter 6- by 100-ft channel leading into Old Pass Lagoon. Unfortunately, the volumes for the main channel are listed as one figure, and it is not possible to determine what proportions of the total volume were dredged from within the inlet, from the North Channel, or from the ebb-tidal shoal. In addition, the records are incomplete regarding the disposal of dredged sand. During the 1960's, some sand was placed on a low island north of the tip of Santa Rosa Island. During project construction and possibly as late as 1972, sand was placed along the gulf shore of Santa Rosa Island west of the west jetty and along the Destin beach east of the east jetty. Since 1972, it appears that all dredged sand has been used to renourish Norriego Point and the area around the landward end of the east jetty. To the best of knowledge, the growth of the ebb-tidal shoal has been natural and has not been augmented by made-made deposition.

The curve labeled "East P + Old P" (Figure 34) is the addition of the volumes from the main channel and Old Pass Channel. The following discussion is based on this combination curve. From 1931 to 1951, about 17,000 cubic yards/year of sand was dredged to maintain a 6- by 100-ft channel. From 1951 to 1991, in order to maintain a 12- by 180-ft channel, dredging increased to 97,000 cubic yards/year. This is reflected in the steepening of the curve starting in 1951. The rubble-mound jetties were built in 1967 and 1968. However, during the 20 years following construction, the dredging rate remained unchanged. A dip in the curve in 1968 probably

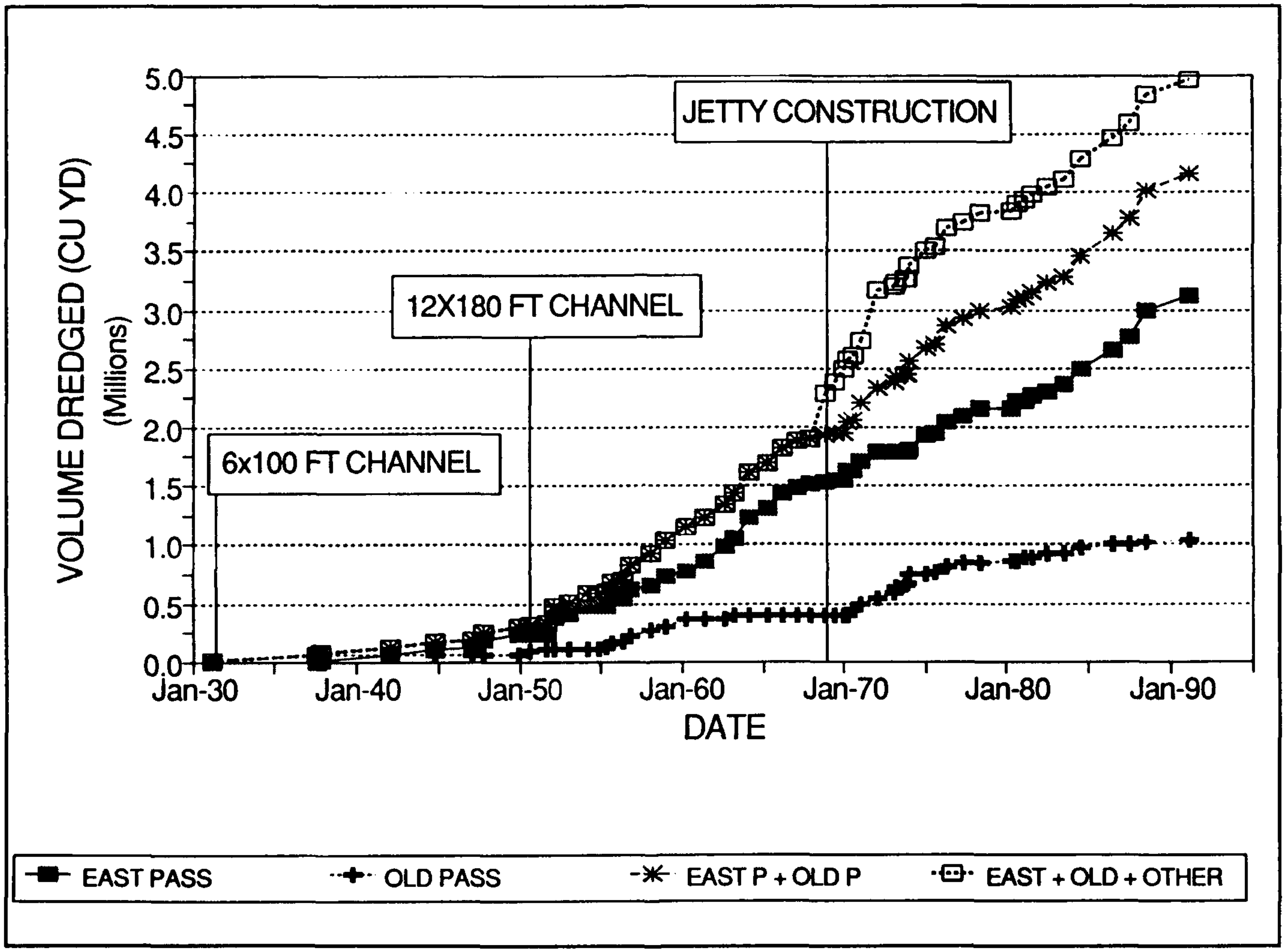

Figure 34. Cumulative dredging volumes, 1931-1991, East Pass and Old Pass Channels and Deposition Basin

reflects inaccuracies in reporting from where sand was removed. As part of the project, the deposition basin near the west jetty was dredged. It is likely that the East Pass Channel was also dredged at this time, but the channel volume was included in the volume listed for the deposition basin.

The fourth curve in Figure 34, marked with a box symbol, includes the dredging volume from the deposition basin. The steepening of the curve beginning in 1969 shows when the basin was dredged. After 1972 dredging of the basin was discontinued.

Analysis of Channel Shoaling

Information on sedimentation patterns and the effect of dredging is revealed by plotting profiles across the inlet. The numerical designation of the lines refers to station fixes on the west jetty. The x-axis of the plots is the distance in feet from the centerline of the west jetty. Depths are corrected to MLW. These data were digitized from bathymetric charts prepared by the Panama City Area Office.

Profiles from sta 32+00, adjacent to the southernmost of the condominiums on Norriego Point are shown in Figure 35. The February and June curves show the inlet before and immediately after dredging. By September, 40 percent of the sand had returned to the navigation channel, and the bottom had shoaled from -15 ft MLW to about -13 ft. However, during this time the natural channel along the east shore remained over 15 ft deep. The east shore was steeper in June and September because dredged sand was placed along the beach, which had suffered serious erosion. The profiles from sta 44+00 (Figure 36), just north of the spur jetty, display a similar pattern: within 3 months after dredging, 33 percent of the sand returned to the navigation channel.

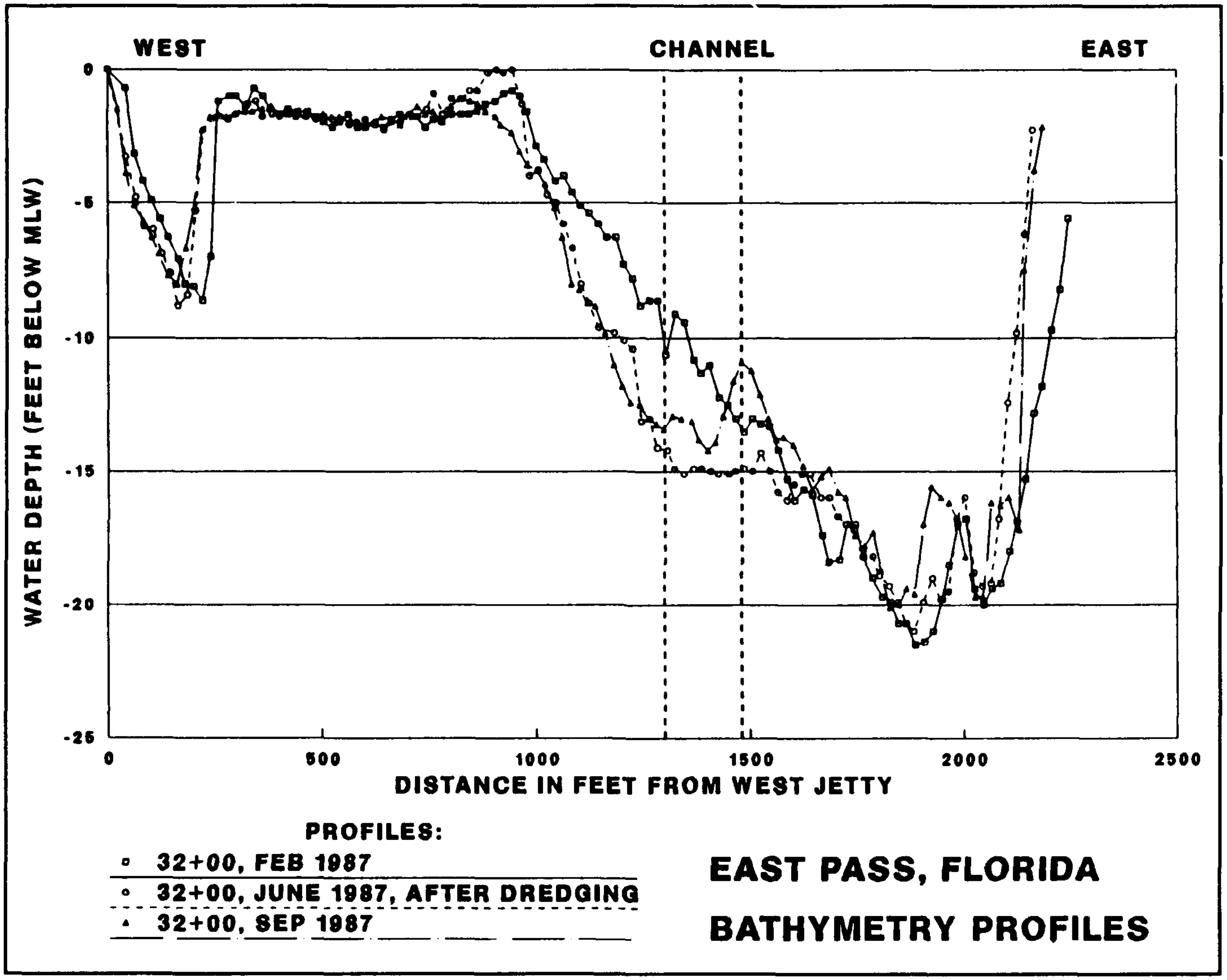

Figure 35. Profiles across East Pass Inlet, Line 32+00, 1987

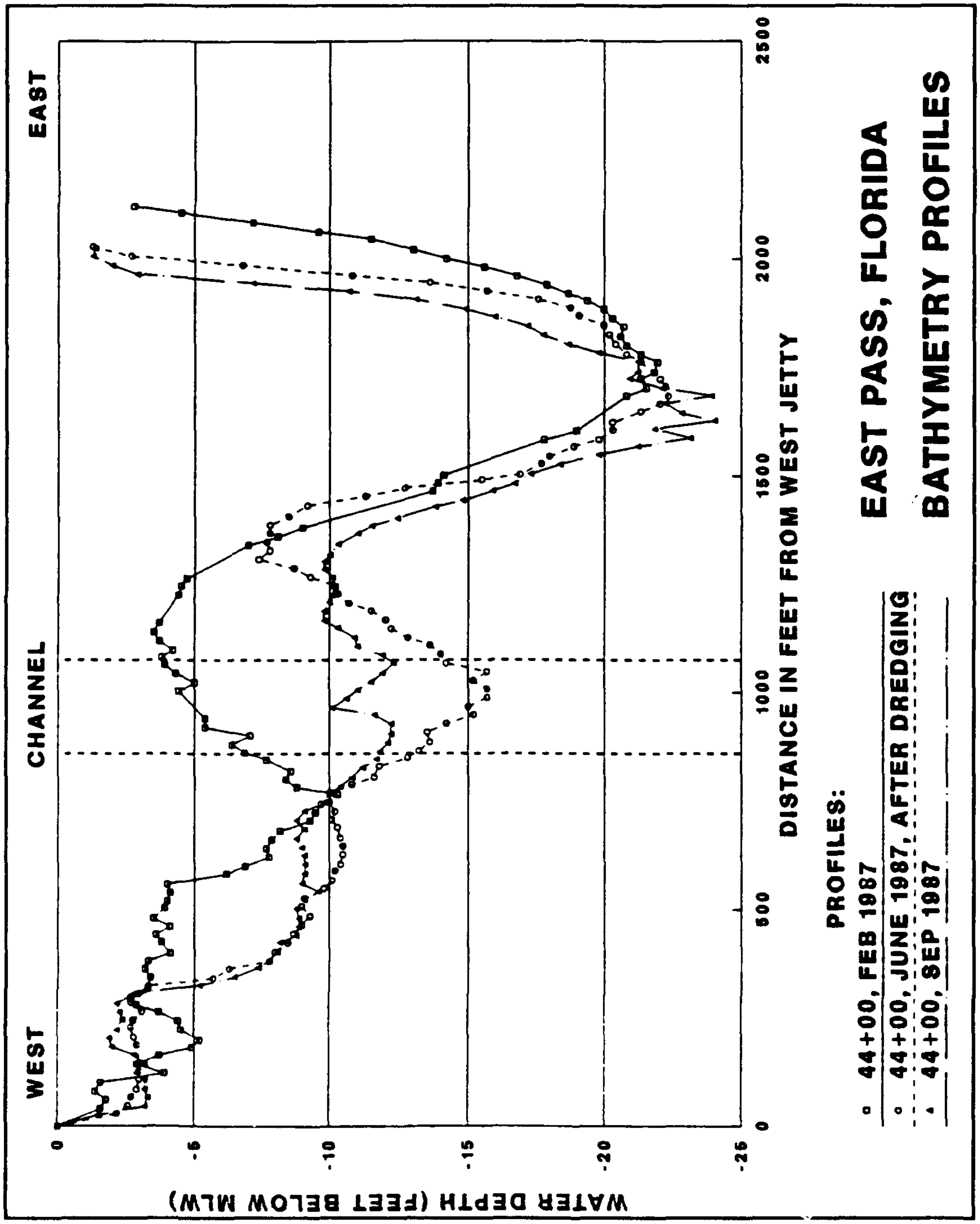

Figure 36. Profiles across East Pass Inlet, Line 44+00, 1987

6 Summary and Recommendations

General

How has the Federal Project at East Pass performed since the jetties were built in 1967-69? Based on the historical review and on the analyses of the data collected during this monitoring project, it is this author's opinion that in many ways the project has performed as the original designers intended. Navigation through the inlet has been enhanced because the following have been accomplished:

a. The mouth of the inlet has been stabilized for the past 22 years, and the jetties have (at least temporarily) stopped the inlet's eastward migration.

b. The structural design of the jetties was sound, and they have suffered only minor damage (the original sheet-pile weir failed and the spur jetty, built later, has partly slumped).

c. The weir did allow littoral drift to enter the deposition basin.

d. Maintaining the 12-ft-deep channel has required annual dredging of 97,000 cu yd, within the predicted range.

Despite these positive accomplishments, a sense of failure or disappointment is often expressed with respect to the East Pass project. The author believes that this disappointment is to some extent a function of perceptions or goals that have changed over the years. Possibly the public expected that the engineering works at the site would eliminate most of the shoaling, stabilize the inlet indefinitely, allow navigation in all weather, last forever, and require minimal maintenance. In reality, some serious geologic and engineering problems have developed at East Pass. The following paragraphs summarize some of the findings of this monitoring project.

Geological Effects of the Jetties

Geological evidence suggests that the jetties have reduced the amount of sand entering the inlet. Bayward transport of sand in the past is indicated by the large flood-tide shoal, the similarity of sand samples from within the inlet to those found along the Gulf of Mexico shore, the growth of Norriego sand spit in a northwest direction, the constant shoaling in the mouth of Old Pass Lagoon, and the rapid filling of the deposition basin after it was initially dredged. Before the erection of the jetties, Norriego Point was gradually migrating northeast, but it was not decreasing in overall size, indicating that erosion and deposition were in balance. However, since project construction ended, the east shore of the inlet has suffered continuous erosion while natural processes (such as overwashing or the landward migration of subaqueous sand bars) have been ineffective at renourishing Norriego Point. This suggests that the sand in littoral transport is now bypassing the mouth of the inlet. Some of this sand may be accumulating on the ebb-tidal shoal, but since the beaches to the east and west of the shoal are not eroding, it is reasonable to assume that a significant proportion of the sand bypasses.

Although some of the sand in littoral transport has been deposited on the ebb-tide shoal, the arrowhead configuration of the jetties may result in flow fields that are unable to carry much sand into the inlet. During the flood at the seaward end of an unjettied inlet, the inflowing water uniformly converges in a semicircular pattern towards the inlet's throat (Oertel 1988). It is unclear how the source field behaves at an inlet with seaward-projecting jetties, but it is likely that the streamlines wrap around the projecting jetties, resulting in turbulence and generally low velocities near the mouth. This is in contrast to the ebb tide, which exits the inlet as a jet, often at high velocity (Unluata and Ozsoy 1977).

The geological model presented in this report proposes that East Pass Inlet periodically breaks through Santa Rosa Island and subsequently turns and migrates in a northeast direction until it reoccupies its original, prebreakout channel. There are no historical data to measure how many years are required for a complete cycle. Based on the stability of the inlet from 1871 to 1928 and on the eastward movement of the inlet after the 1928 breakthrough, it appears that a cycle might take about 100 years.

The following evidence supports the hypothesis that physical processes are still attempting to force the inlet east:

a. Norriego Point is eroding.

b. The thalweg migrated east within the inlet after the jetties were built. It now hugs the east shoreline from the spur jetty north for about 2,000 ft.

Based on field data collected in this project, the driving forces of the eastward migration are believed to be:

a. *Wave forces.* The predominant wave direction from 1987 to 1990 was from the southwest while the shoreline trends approximately east-west.

b. *Currents within the inlet.* The geometry of the flood-tidal shoal and its associated channels cause the currents south of the highway bridge to flow northwest-southeast. Since the currents flow through the jetties in a north-south direction, they must turn in the region between the jetties and the highway bridge. The inlet's east shore (Norriego Point), being the outer side of this turn, is eroded by the tremendous amount of water flowing against it. Because of freshwater inputs, the ebb often is longer in duration and higher in velocity than the flood. In 1984, the ebb flow was measured to be almost 100,000 cu ft/sec for over 8 hr. Flowing towards 120 deg in the area south of the highway bridge, the ebb flow is forced against the inlet's east shore.

An important question at this juncture is how have the jetties affected the geologic cycle proposed in the model? Temporarily, the jetties have arrested the eastward movement of the inlet's mouth. However, how long can man-made structures retard powerful natural forces? And at what maintenance costs? These troubling questions have no simple answers, but all evidence indicates that maintaining the present inlet will be increasingly difficult.

Weir

The former weir has been one of the most contentious parts of the East Pass project. Was it placed on the "wrong" side? No. It allowed littoral drift to enter the inlet and settle into a deposition basin. After the weir was closed in 1986, the beach west of the west jetty grew seaward, confirming that eastward-flowing littoral currents carry a significant amount of sand.

Perhaps a more important question is: can it be concluded that a weir on the east side would have performed any better? No. One can speculate that an east weir would have allowed sand to enter the east side of the inlet, where it would have been available to renourish Norriego Point. However, this sand, carried north by the flood currents, would probably have aggravated an already serious shoaling problem in the mouth of Old Pass Lagoon. The project designers had a legitimate concern that the jetties might cause the downdrift beach to become sand-starved and therefore erode. Although the direction of the net drift was unknown, there was evidence that the longshore currents changed directions in the East Pass area. Therefore, two weirs should have been built and carefully monitored until it was clearly established whether one, or neither, should be closed.

The original sheet-pile weir was incorrectly designed, and it collapsed within a few months after construction ended. The repair with a rubble-mound structure similar to the main jetties was entirely successful.

The long-term functioning of the weir as a mechanism to allow sand to be bypassed by dredge to the other side of the inlet is unknown because the deposition basin was dredged only from 1968 to 1972. The reasons for discontinuing basin dredging are obscure. During the first few years after construction ended, the entire inlet system was adjusting to the new jetties, and the weir's performance during this period may not have been representative of the longer term. One lesson from East Pass is that a project should be maintained as designed unless long-term or overwhelming evidence indicates that changes are needed.

Based on the current measurements made in 1983, 1984, and 1987, the weir had negligible effects on the tidal hydraulics of the inlet. The reason for this is that the amount of water flowing over the weir was minuscule compared with the amount flowing through the inlet proper.

Dredging Recommendations

The time-history of dredging at East Pass reveals that the dredging rate has remained the same between 1951 and 1991, despite the construction of the jetties. A reduction in the amount of dredging needed to maintain a 12-ft-deep channel within the inlet might be possible if the navigation channel were realigned to follow more closely the natural thalweg. Profiles across the inlet north of the spur jetty show that while the navigation channel shoals rapidly after dredging, the thalweg remains deeper than 12 ft over time. In recent years, USAED, Mobile, has moved the navigation channel to follow the western flank of the thalweg in the area near the spur jetty. Before making a more comprehensive change, economic and practical factors, such as the location of the bridge spans, the cost of moving navigation markers, and the alignment of the proposed channel, would have to be carefully studied. Objections might be raised that if the channel followed the thalweg, boat wakes might aggravate the erosion along the east shore. Although some effect from boat wakes is possible, natural processes have directed the flow of water along the east side of the inlet, resulting in steep sides and an ongoing erosion problem. In addition, it is likely local fishermen and boaters already use the natural channel since they are doubtlessly aware that the official navigation channel is often shallower than the authorized 12 ft. Figure 37 shows the location of the present navigation channel and the thalweg in February 1990. The dashed line north of the spur jetty shows the area where the navigation channel possibly could be relocated to take advantage of the naturally deep thalweg.

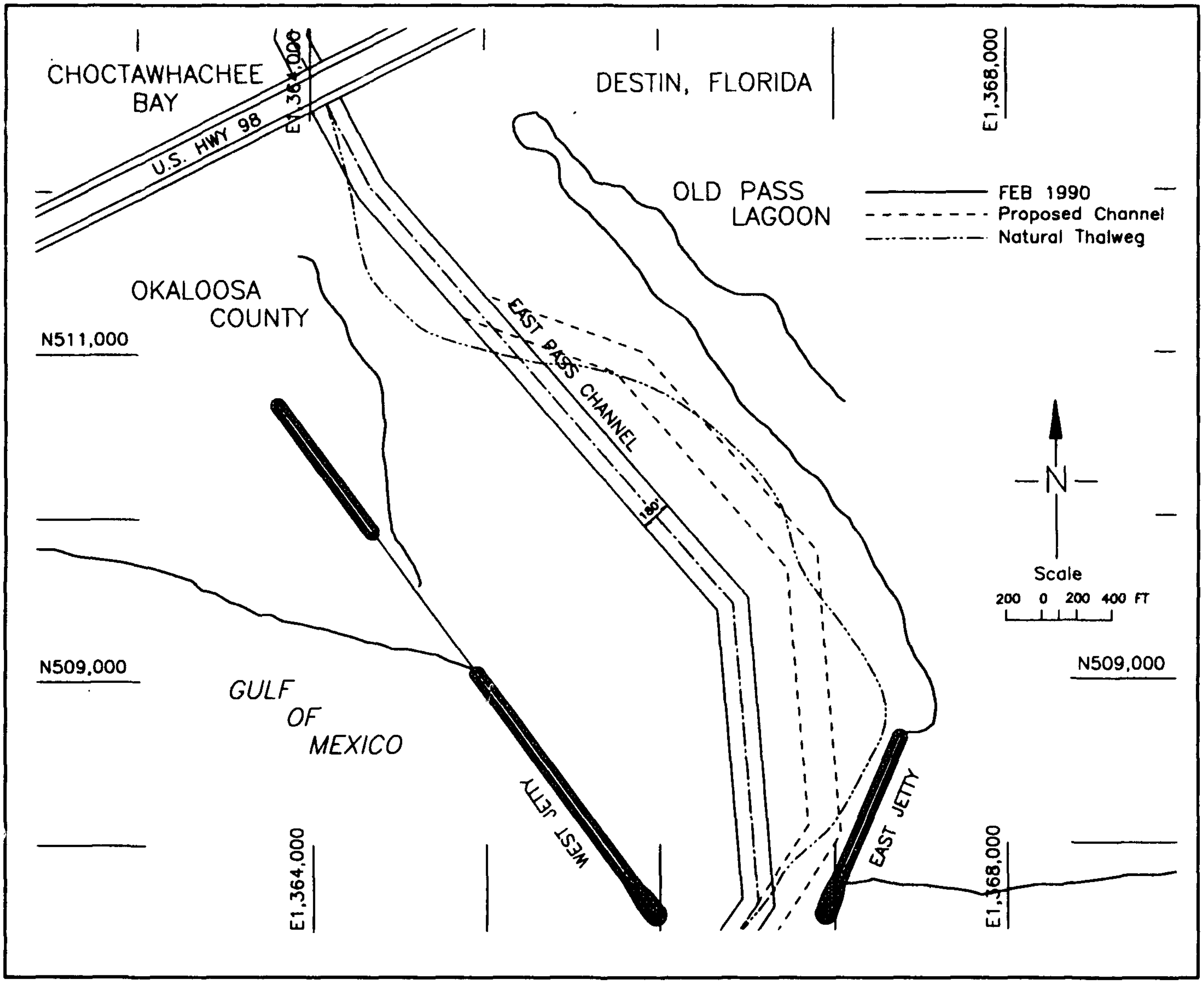

Figure 37. Location of present navigation channel and location of thalweg. Dotted line represents possible channel relocation

How much of a reduction in dredging can be expected by relocating the channel to follow the thalweg? For the zone within the inlet proper, the savings might be significant. However, it is not likely to achieve a similar improvement over the unprotected ebb-tidal shoal. Here, the thalweg meanders and frequently changes its course, whereas the navigation channel follows a straight line from the Gulf of Mexico to the mouth of the inlet (Figure 3). It would be impossible to try to relocate it each time the thalweg moved, especially in winter when storms are more frequent. Fortunately, for most of the channel's route over the shoal, the water depth is over 12 ft. Nevertheless, shoaling in some areas will occur and occasional dredging will be needed.

Another way to reduce dredging in East Pass would be to reduce the depth of the maintained channel. The cumulative dredging curve (Figure 33) shows that the 6-ft channel required less than 20 percent of the annual dredging that the 12-ft channel needed. A decision to change the dimensions of the navigation project would require a thorough survey of the types of vessels using the inlet and an analysis of the economic impacts such a change might produce. Unofficial inquiries by the author at Eglin AFB revealed that Air Force patrol boats no longer transit East Pass. Moreover, few if any of the boats in Destin seem likely to need a 12-ft depth. Even a decrease of only 2 ft to a 10 ft-deep channel might significantly reduce the required dredging.

Engineering Summary

One of the primary objectives of this MCCP monitoring project, as outlined in the Monitoring Program (USAED, Mobile 1986) was to evaluate how the stability of the jetty system could be improved. The eastward migration of the inlet over time has been documented, and as long as this process continues, scour and damage to the east jetty and erosion to Norriego Point will continue. The following are proposed as partial solutions to some of the stability and maintenance problems in East Pass. Note that realignment of the navigation channel, as discussed in the previous section, may reduce the maintenance dredging but will not affect scour at the jetties nor reduce the eastward migration of the thalweg.

a. Pertaining to overall stability, East Pass could be rerouted to follow the Old Pass Lagoon Channel. This route had been stable for over 55 years before the 1928 breakthrough. Even today, the currents measured south of the highway bridge flow in directions similar to the orientation of Old Pass Lagoon.

b. If the existing East Pass Inlet is to be maintained, the following practices might reduce Norriego Point erosion.

   (1) The shoreline facing the inlet, from the northern tip of Norriego Point to the north end of the east jetty (5,000 ft) could be

armored. This would be a major engineering effort because extensive toe protection would be needed to prevent scour. An alternative might be a sheet-pile wall with a scour apron.

(2) A guide wall or series of walls could possible be built to deflect currents away from Norriego Point. Physical models would be necessary to test alternative designs. The walls' effect on flushing of Old Pass Lagoon would have to be investigated, as would their impact on navigation.

(3) A dredge could be kept onsite to dredge the Old Pass Lagoon entrance channel whenever necessary and renourish Norriego Point.

c. The following might prevent scour at the jetties.

(1) The spur jetty can be rebuilt with extensive toe protection to prevent collapse. The scour hole near the tip of the spur would have to be filled and then armored to prevent future scour. While the use of concrete and rubble fill in the past provided only temporary relief, an engineered approach employing precisely placed armor units might be more successful. A design using graded-stone layers might also be successful.

(2) The scour hole at the tip of the west jetty should also be filled and capped with armor stone to prevent damage to the jetty.

It must be emphasized that a comprehensive engineering study would be necessary before any of these, or other, alternatives could be implemented. It would also be necessary to evaluate how construction or modification in one part of the inlet might affect processes in another part. While the field monitoring that has been conducted as part of this MCCP project can shed little information on the effectiveness and overall effects of specific alternative designs, physical modeling would be more enlightening because of the possibilities of testing a wide range of environmental conditions.

Data specifically relating to armor stone displacement and jetty settlement were not collected during this project. Based on the author's field visits to the site and the analyses of hydrographic surveys, the following conclusions can be made:

a. The west jetty is in overall good condition. A scour hole is developing at the seaward end and may eventually become deep enough to cause damage.

b. The spur jetty is deteriorating rapidly and is only about 100 ft long (as of March 1991). The armor stone is slumping into a large scour hole.

c. The east jetty appears to be in good condition. If the shoreline continues to erode immediately north of the landward (northern) end of the jetty, the jetty may eventually be bypassed by a new channel that runs in a northwest by southeast direction. This might follow an alignment similar to that of a channel that existed here in the 1960's before the jetties were built (the channel on the right in Figure 7).

An important lesson, based on the historical records (Appendix A) and the findings of this monitoring study, is that a project should be maintained as designed unless overwhelming field evidence or unexpected natural events such as hurricanes clearly indicate that a change in operations and maintenance are required. If maintenance practices are frequently adjusted, it is almost impossible to determine how successfully the project has performed and what lessons can be learned to improve future projects. For example, the investigators are unable to evaluate the effectiveness of the weir at East Pass because dredging of the deposition basin was discontinued after 1972. Ultimately, all people involved with a coastal project like East Pass must bear in mind that the coastal environment is exceedingly complex and is subject to many forces and processes, the nature of which is still little understood.

References

Angell, J. W., Jr. 1944. *History of the Army Air Forces Proving Ground Command, Part One, Background of Eglin Field 1933-1940*, Reprinted March 1989 by Air Force Development Test Center, Office of History, Eglin Air Force Base, FL.

Aubrey, D. G., and Speer, P. E. 1984. "Updrift Migration of Tidal Inlets," *Journal of Geology*, Vol 92, pp 531-545.

Carter, R. W. G. 1988. *Coastal Environments; an Introduction to the Physical, Ecological and Cultural Systems of Coastlines*, Academic Press, London.

FitzGerald, D. 1988. "Shoreline Erosional-Depositional Processes Associated with Tidal Inlets," In: Aubrey, D. G., and Weishar, L., Eds., *Hydrodynamics and Sediment Dynamics of Tidal Inlets*, Lecture Notes on Coastal and Estuarine Studies, Vol 29, Springer-Verlag, New York, pp 186-225.

Goldsmith, V. 1966. "The Recent Sedimentary Environment of Choctawhatchee Bay, Florida," M.S. Thesis, Florida State University, Tallahassee, FL.

Gorsline, D. S. 1966. "Dynamic Characteristics of West Florida Gulf Coast Beaches," *Marine Geology*, Vol 4, pp 187-206.

Horikawa, K., Ed. 1988. *Nearshore Dynamics and Coastal Processes, Theory, Measurement, and Predictive Models*, University of Tokyo Press, Tokyo, Japan.

Huh, O. K., Rouse, L. J., Jr., and Walker, N. D. 1984. "Cold Air Outbreaks Over the Northwest Florida Continental Shelf: Heat Flux Processes and Hydrographic Changes," *Journal of Geophysical Research*, Vol 89, No. C1, pp 717-726.

Huh, O. K., Wiseman, W. J., Jr., and Rouse, L. J., Jr. 1978. "Winter Cycle of Sea Surface Thermal Patterns, Northeastern Gulf of Mexico," *Journal of Geophysical Research*, Vol 83, No. C9, pp 4523-4529.

Huh, O. K., Wiseman, W. J., Jr., and Rouse, L. J., Jr. 1981. "Intrusion of Loop Current Waters onto the West Florida Continental Shelf," *Journal of Geophysical Research*, Vol 86, No. C5, pp 4186-4192.

Kwon, H. J. 1969. "Barrier Islands of the Northern Gulf of Mexico Coast: Sediment Source and Development," Technical Report 75, Coastal Studies Institute, Louisiana State University, Baton Rouge, LA.

Levin, D. R. 1983. "East Pass: Evidence of Anomalous Eastward Longshore Sediment Transport," In: *Sedimentary Processes and Environment along the Northeast Coast of the Gulf of Mexico*, Louisiana State University Coastal Research Technical Report 83-2, Louisiana State University, Baton Rouge, LA, pp 122-129.

Longuet-Higgins, M. S., Cartwright, D. E., and Smith, N. D. 1963. "Observations of the Directional Spectrum of Sea Waves Using the Motions of a Floating Buoy." In: *Ocean Wave Spectra*, Prentice-Hall, Englewood Cliffs, NJ, pp 111-136.

MacNeil, F. Stearns. 1949. "Pleistocene Shore Lines in Florida and Georgia," *Shorter Contributions to General Geology*, Geological Survey Professional Paper 221-F, Washington, DC, pp 95-106.

Massoni, J. 1988. *Camp Pinchot*, Air Force Development Test Center, Office of History, Eglin Air Force Base, FL.

Morang, A. 1990. "Quality Control and Management of Oceanographic Wave-Gage Data," Instruction Report CERC-90-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Oertel, G. F. 1988. "Processes of Sediment Exchange Between Tidal Inlets, Ebb Deltas, and Barrier Islands," In: Aubrey, D. G., and Weishar, L., Eds., *Hydrodynamics and Sediment Dynamics of Tidal Inlets*, Lecture Notes on Coastal and Estuarine Studies, Vol 29, Springer-Verlag New York, pp 297-318.

Otvos, E. G. 1982. "Santa Rosa Island, Florida Panhandle, Origins of a Composite Barrier Island," *Southeastern Geology*, Vol 23, No. 1, pp 15-23.

Roberts, H. H., Huh, O. K., Hsu, S. A., Rouse, L. J., Jr., and Rickman, D. 1987. "Impact of Cold-Front Passages on Geomorphic Evolution and Sediment Dynamics of the Complex Louisiana Coast," *Proceedings of Coastal Sediments '87*, American Society of Civil Engineers, New Orleans, LA, 12-14 May 1987, pp 1950-1963.

Sargent, F. E. 1988. "Case Histories of Corps Breakwater and Jetty Structures; Report 2, South Atlantic Division," Technical Report REMR-CO-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schroeder, W. W., Dinnel, S. P., Wiseman, W. J., Jr., and Merrell, W. J., Jr. 1987. "Circulation Patterns Inferred from the Movement of Detached Buoys in the Eastern Gulf of Mexico," *Continental Shelf Research*, Vol 7, No. 8, pp 883-894.

Shore Protection Manual. 1984. 4th Ed., 2 Vols, US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, US Government Printing Office, Washington, DC.

Simpson, R. H., and Riehl, H. 1981. *The Hurricane and Its Impact*, Louisiana State University Press, Baton Rouge, LA.

Snetzer, R. F. 1969. "Jetty-Weir Systems at Inlets in the Mobile Engineer District," *Shore and Beach*, Vol 37, No. 1, pp 28-32.

Sonu, C. J., and Wright, D. L. 1975. "Mass Transport and Dispersion off a Tidal Inlet," *Seventh Annual Offshore Technology Conference*, Houston, TX, Paper OTC 2383, pp 489-498.

Stone, G. W. 1990. "Differential Sediment Supply and Longshore Sediment Transport Along Coastal Northwest Florida and Southeast Alabama Since the Late Holocene," Ph.D. Dissertation, University of Maryland, College Park, MD.

Swanson, V. E., and Palacas, J. G. 1965. "Humate in Coastal Sands of Northwest Florida," *Contributions to Geochemistry*, Geological Survey Bulletin 1214-B, US Government Printing Office, Washington, DC.

Tanner, W. F. 1964. "Nearly Ideal Drift System Along the Florida Panhandle Coast," *Annals of Geomorphology*, Vol 8, No. 3, pp 334-342.

__________. 1970. "Significance of Camille," *Southeastern Geology*, Vol 12, No. 2, pp 95-104.

Unluata, U. A., and Ozsoy, E. 1977. "Tidal Jet Flows near Inlets," *Hydraulics in the Coastal Zone*, American Society of Civil Engineers, New York, pp 90-98.

US Army Engineer District, Mobile. 1963. "Survey Report on East Pass Channel from the Gulf of Mexico into Choctawhatchee Bay, Florida," Report to the Division Engineer, South Atlantic Division, Atlanta, GA.

US Army Engineer District, Mobile. 1967. "General Design Memorandum on East Pass Channel, Florida, from the Gulf of Mexico into Choctawhatchee Bay," Memorandum to the Division Engineer, South Atlantic Division, Atlanta, GA.

__________. 1972. "Evaluation of Jetty-Weir Systems at Perdido Pass, Alabama, and East Pass, Florida," Memorandum prepared for the Coastal Engineering Research Center, Fort Belvoir, VA.

__________. 1977. "Design Report on East Pass Channel, Florida-Shoreline Improvement and Dune Stabilization," Report to the Division Engineer, South Atlantic Division, Atlanta, GA.

__________. 1982. "Reconnaissance Report, East Pass Channel," Destin, FL.

__________. 1986. "Monitoring Program, East Pass Channel," Destin, FL.

US Engineer Office, Mobile. 1939. "Study of East Pass Channel, Choctawhatchee Bay, Florida," Report to the Division Engineer, Gulf of Mexico Division, New Orleans, LA.

US Congress. House. 1928. Letter from the Secretary of War. East Pass Channel from the Gulf of Mexico into Choctawhatchee Bay, Fla. 70th Congress, 1st Session. House Document 209.

US Congress. House. 1950. Letter from the Secretary of the Army. East Pass from the Gulf of Mexico into Choctawhatchee Bay, Fla. 81st Congress, 2nd Session. House Document 470.

US Department of Commerce. 1990. "Tide Tables 1990, High and Low Water Predictions, East Coast of North and South America Including Greenland," National Oceanic and Atmospheric Administration, National Ocean Survey, Washington, DC.

Walton, T. L., Jr. 1973. "Littoral Drift Computations Along the Coast of Florida by Means of Ship Wave Observations," Technical Report No. 15, Coastal and Oceanographic Engineering Laboratory, University of Florida, Gainesville, FL.

Wang, Y. H., Howard, W. W., Chang, T. H., and Smutz, M. 1978. "Littoral Sand Transport Near Panama City Beach, Florida," UFL/COEL Report 78/011, Coastal and Oceanographic Engineering Laboratory, University of Florida, Gainesville, FL.

Williams, J. L. 1827. *A View of West Florida Embracing Its Geography, Topography*, (1976 facsimile reproduction), Bicentennial Floridiana Facsimile Series, University of Florida, Gainesville, FL.

Wright, L. D., and Sonu, C. J. 1975. "Processes of Sediment Transport and Tidal Delta Development in a Stratified Tidal Inlet," In: Cronin, L. E. ed., *Estuarine Research*, Vol 2, Academic Press, Inc., New York, pp 63-76.

Appendix A
Chronological Listing of Cultural and Natural Events

Table A1
Chronology of Cultural and Natural Events and Developments East Pass, Florida, and Vicinity, 1827-1990

Date	Event	Description	Reference[1]
1827	Book & map	*A View of West Florida Embracing Its Geography, Topography* by John L. Williams	1976 Facsimile Reproduction
Dec 1828	Forest	John Quincy Adams established 30,000-acre oak preserve on Santa Rosa Island.	Angell 1944
1845	Town	New London fishing master, Captain Destin, founded town of Destin for red-snapper fishing.	Angell 1944
1861	Civil War	Union frigate anchored in East Pass to blockade Choctawhatchee Bay.	Angell 1944
1886	Hurricane	(No details)	Angell 1944
1896	Hurricane	(No details)	Angell 1944
1906	Hurricane	(No details)	Angell 1944
8 Jan 1912	Report	Preliminary exam re: deeper channel.	H Doc 424, 62nd Cong., 2nd Sess.
4 Jan 1924	Report	Proposals for 12-, 18-, or 20-ft channels. Possibly put forward by proponents of Port Dixie, who planned a major seaport on Choctawhatchee Bay.	Cited in H Doc 470 and Angell 1944
20 Sep 1926	Hurricane	Reduced depth of East Pass to 3-1/2 ft; extensive damage to Pensacola wharfs.	House Doc 209
29 Mar 1928	Report	Recommended 6-ft deep nav. channel, annual maintenance estimated at $600. Natural channel depth about 8 ft after periods of fair weather, but usually only 6 ft. Gulf end of East Pass has been moving westward for years. Both North and East Channels (in Choctawhatchee Bay) reported to be shoaling.	H Doc 209, 70th Cong., 1st Sess.
Apr 1928	Storm	Severe storm and high tide partially breached Santa Rosa Island near present East Pass.	H. Doc 470
12-15 Mar 1929	Breach	16-in. rain in 48 hr caused record floods on Choctawhatchee River. Bay rose 5 ft. Local inhabitants dug pilot channel along 1928 breach to expedite runoff. Channel rapidly enlarged.	H. Doc 470, Mobile 1939 and Angell 1944

(Continued)

[1] References cited in this appendix are located at the end of the main text.

(Sheet 1 of 10)

Table A1 (Continued)			
Date	**Event**	**Description**	**Reference**
29-30 Sep 1929	Hurricane	Winds hurricane force for 8 hr at Pensacola. Max speed over 100 mph.	Mobile 1939 report
3 Jul 1930	Projects	6- by 100-ft channel project in (new) East Pass initiated.	Mobile 1939 report
Apr 1931	Dredging	Old Pass Channel 20,000 cu yd $8600.	1931 Ann. rep.
Jun 1931	Shoaling	Old East Pass shoaled to 2 ft deep.	1931 Ann. rep.
Nov 1932 to 1933	Bridge	US Hwy 98 bridge built; fixed span, 42-ft clearance.	H. Doc 470
1935	Shoaling	Gulf entrance of Old East Pass almost filled.	Mobile 1939 report
1935	Spit	Norriego Point sand spit formed.	Mobile 1939 report
Jun 1936	Flood	Choctawhatchee Bay rose 5 ft, Hwy 98 cut 3 miles W of East Pass.	Mobile 1939 report
31 Jul 1936	Hurricane	Max winds 62 mph at Pensacola. Much damage in Valpariso and Niceville.	Mobile 1939 report
25 Mar 1937	Eglin Field	Valpariso Airport became Federal property. This dirt strip grew to become Eglin Field	Angell 1944
30 Apr 1937	Hurricane	Max winds 52 mph at Pensacola.	Mobile 1939 report
Aug 1937	Dredging	Old Pass Channel: 39,100 cu yd.	Mobile 1939 report
Dec 1937	Dredging	East Pass Channel: 22,300 cu yd.	Mobile 1939 report
1938	Shoal erosion	Ebb-tidal shoal in front of Old East Pass outlet completely eroded; isobaths now parallel to shoreline.	Mobile 1939 report
Apr 1938	Canal	9- by 100- ft dredged canal completed from Choctawhatchee to St. Andrews Bay.	Mobile 1939 report
Apr-Jun 1938	Studies	Field measurements made for report. Floats showed west-flowing littoral current.	Mobile 1939 report
8 Nov 1938	Site visit	Site visit by Francis Escoffier, interviews with local fishermen.	Mobile archives
12 Jun 1939	Report	"Study of East Pass Channel Choctawhatchee Bay, Florida," Highly detailed with hydraulic analyses, shoreline changes.	Mobile archives

(Continued)

(Sheet 2 of 10)

Table A1 (Continued)

Date	Event	Description	Reference
27 Jun 1940	Eglin	Choctawhatchee National Forest becomes part of Eglin Field (Pub. No. 688, 76th Congress). Entire area over 600 square miles.	Angell 1944
1940-1945	Eglin	Tremendous growth of Eglin's activities during WW II. HQ of Army Air forces Proving Ground Command. Many tests conducted over Gulf of Mexico.	Angell 1944
Mar 1942	Dredging	East Pass Channel: 43,700 cu yd; cost: \$7,400.	1942 Ann. rep.
Oct 1944	Dredging	East Pass Channel: 46,100 cu yd; cost: \$7,600.	1945 Ann. rep.
Jun 1945	Dredging	12- by 180-ft channel dredged to support Eglin Air Force Base (AFB) boats - funded by Army Air Forces.	H. Doc 470
12 Jul 1945	Hearing	Civic and business leaders request 20-ft channel. Also request to reopen old East Pass to reduce erosion on Moreno Point.	H. Doc. 470
Mar 1947	Dredging	East Pass Channel: 19,300 cu yd; cost: \$3,300.	1947 Ann. Rep.
Nov 1947	Dredging	East Pass Channel: 59,100 cu yd; cost: \$29,000.	1948 Ann. Rep.
Jan 1950	Dredging	East Pass Channel: 41,800 cu yd; cost: \$15,000.	1950 Ann. Rep.
14 Feb 1950	Report	Cites Eglin AFB activities along with commercial fishing and pleasure craft as reasons to continue supporting 12- by 180-ft channel in East Pass and 6- by 100-ft channel to Destin. Predominant longshore drift said to be westward. Estimate 150,000 cubic yards/year dredging needed.	H. Doc 470, 81st Cong. 2nd Sess.
Sep 1950	Dredging	Old Pass Channel: 25,500 cu yd; cost: \$7,000.	1951 Ann. Rep.
Sep 1951	Dredging	Old Pass Channel: 16,200 cu yd; cost \$5,000.	1952 Ann. Rep.
Feb-Apr 1952	Dredging	East Pass Channel: 139,200 cu yd; cost: \$13,000.	1952 Ann. Rep.
Jan 1953	Dredging	East Pass Channel: 38,700 cu yd; cost: \$18,600.	1953 Ann. Rep.
Apr 1954	Dredging	East Pass Channel: 67,700 cu yd; cost: \$18,600.	1954 Ann. Rep.

(Continued)

(Sheet 3 of 10)

Table A1 (Continued)			
Date	**Event**	**Description**	**Reference**
Dec 1954	Dredging	Old Pass Channel: 11,700 cu yd; cost $1,800.	1955 Ann. Rep.
May 1955	Dredging	Old Pass Channel: $10,800 cu yd; cost: $3,800.	1956 Ann. Rep.
Aug 1955	Dredging	East Pass Channel: 56,300 cu yd; Old Pass Channel: 27,700 cu yd.	1956 Ann. Rep.
May 1956	Dredging	Old Pass Channel: 22,000 cu yd; total cost FY 1956: $28,600.	1956 Ann. Rep.
Nov 1956	Dredging	East Pass Channel: 75,900 cu yd; Old Pass Channel: 51,700 cu yd; total cost: $27,200.	1957 Ann. Rep.
Aug 1957 Feb 1958 Mar 1958	Dredging	East Pass Channel: 43,600 cu yd; Old Pass Channel: 52,800 cu yd; total cost: $28,300.	1958 Ann. Rep.
Feb 1959	Dredging	East Pass Channel: 81,700 cu yd; Old Pass Channel: 28,900 cu yd; total cost: $26,800.	1959 Ann. Rep.
Mar-May 1960	Dredging	East Pass Channel: 45,800 cu yd; Old Pass Channel: 63,100 cu yd; total cost: $31,000.	1960 Ann. Rep.
May-Jun 1961	Dredging	East Pass Channel: 80,600 cu yd; total cost: $35,500.	1960 Ann. Rep.
10 Jan 1962	Letter	Representative Bob Sykes notes deep, swift water off Norriego Point and formation of new ebb channel to west of existing one.	Mobile Archives
Jul-Oct 1962	Dredging	East Pass Channel: 123,800 cu yd; total cost: $44,800.	1962 Ann Rep.
Mar-Apr 1963	Dredging	East Pass Channel: 67,800 cu yd; Old Pass Channel: 18,600 cu yd; total cost: $31,900.	1963 Ann Rep.
Oct 1963	Report	"Survey Report on East Pass Channel from the gulf of Mexico into Choctawhatchee Bay, Florida," recommended channel relocation and construction of jetties.	Mobile Archives
14 Oct 1963	Letter	President of Beach Erosion Board (BEB) states that BEB staff concluded predominant littoral drift is from west to east. Frequent reversals, large total drift, but net eastward drift probably small. Noted that Old East Pass moved E from 1929 to 1935 and closed in 1938 under influence of eastward drift.	Mobile Archives
30 Oct 1963	Letter	District Engineer, Mobile, noted that East Pass might be an example of updrift migration.	Mobile Archives
Feb-Mar 1964	Dredging	East Pass and Old Pass Channels: 170,400 cu yd; total cost: $62,000.	1964 Ann. Rep.
1964	Channel change	New ebb channel formed to west of existing one. Not known if natural processes were aided by dredging.	18 Apr 1967 letter, Mobile Archives

(Continued)

(Sheet 4 of 10)

Table A1 (Continued)			
Date	**Event**	**Description**	**Reference**
1965	Sandbar	Large, arcuate-shaped sandbar along west side of inlet not yet welded to east end of Santa Rosa Island. Possibly served as disposal area for dredged sand.	Aerial photos, Eglin Archives
Apr-May 1965	Dredging	East Pass Channel: 86,500 cu yd; total cost: $40,000.	1965 Ann. Rep.
Sep-Oct 1965	Breach	Breach in Norriego Point caused by Hurricane Betsy was closed by Mobile District personnel	1965 Ann Rep.
Apr 1966	Dredging	East Pass Channel: 136,000 cu yd. Dredging: $25,000; total cost $31,000.	1966 Ann. Rep.
12 Jan 1967	Design Conference	Caldwell and Rayner of Coastal Engineering Research Center (CERC) believed available data inconclusive re. predominant drift. Recommended weirs on both sides.	Mobile Archives
1967 (?)	Migrating Channel	East Pass Channel split into two parts over ebb-tidal shoal: east channel thin, west channel deeper and wider. Canals for property owners dredged in beach east of east jetty; no buildings erected yet. Arcuate sandbar almost welded to east end of Santa Rosa Island.	Aerial photos, Eglin Archives
Mar 1967	Dredging	East Pass Channel: 42,100 cu yd; Old Pass Channel: 6,400 cu yd; costs: $39,600, total: $49,000.	1967 Ann. Rep.
25 Apr 1967	Design Conference	CERC and Office of Chief of Engineers (OCE) recommended one weir only, in west jetty. Jetties to be extended to 6-ft contour only since the 12-ft contour will move landward (!) to the approximate position it held prior to 1963. Anticipated that Norriego spit will erode and will need to be nourished by dredging.	Mobile Archives
Jun 1967	Report	"East Pass Channel, General Design Memorandum," provides original design for jetties.	Mobile Archives
Dec 1967	Dredging	East Pass Channel: 24,600 cu yd; cost: $12,000, total: $18,000.	1968 Ann. Rep.
Dec 1967	Jetties	Jetty construction started.	Snetzer 1969, *Shore and Beach*
Sep-Dec 1968	Dredging	Deposition basin, outerbar, Old Pass Lagoon: 360,000 cu yd; cost: $263,000. East Pass and Old Pass Channels: 282,000 cu yd.	1969 Ann. Rep.
Jan 1969	Jetties	Jetty construction and dredging completed.	Mobile 1982 report
1969	Road	Paved road built on Norriego Point.	Aerial photos, Eglin Archives
Jun 1969	Dredging	Deposition basin: 57,100 cu yd; Old Pass Channel: 15,100 cu yd; East Pass Channel: 10,200 cu yd; cost: $27,000.	1969 Ann. Rep.

(Continued)

(Sheet 5 of 10)

Table A1 (Continued)

Date	Event	Description	Reference
6 Jun 1969	Weir failure	100 ft of weir failed; 40 individual concrete sheet piles had been undermined by scour and had fallen inward toward inlet. Scour holes 20 ft deep reported.	Status report, 20 Jun 1969, Mobile Archives
Jun 1969	Weir failure	More of weir collapsed during repair attempts. Sand pumped into scour areas.	Status report 20 Jun 1969, Mobile Archives
23 Jul 1969	Design Conference	CERC, OCE, and Mobile engineers recommended rock repair of gap in weir and blanket stone on either side of remaining sheet-pile weir. Local interests will not be required to share in cost of restoring the weir.	Mobile Archives
Jul 1969 & Apr 1970	Dredging	East Pass Channel: 80,700 cu yd; cost: $12,000.	1970 Ann. Rep.
4 Sep 1969	Trip report	Inspection after Hurricane Camille showed that rock jetties generally in good condition. On ebb-tidal shoal, natural channel formed to west of marked navigation channel, which had shoaled.	Mobile Archives
5 Dec 1969	Trip report	Channel has eroded through the gap in weir.	Mobile Archives
Feb 1970	Dredging	Deposition Basin and East Pass Channel: 118,500 cu yd; cost $100,000.	1971 Ann. Rep.
Jun 1970	Bridge	Second span of Hwy 98 bridge under construction.	Aerial photos Eglin Archives
17 Jul 1970	Memo For Record	It appeared from aerial photos that sand was moving through the breached weir in <u>both</u> directions. Still lack of firm evidence about direction of predominant littoral drift in area.	Mobile Archives.
Aug 1970	Repair	Repairs to jetty weir cost $196,000. Dredge pumped 53,000 cu yd on landward end of W jetty, 50,000 cu yd on landward end of E jetty.	1971 Ann. Rep.
Aug 1970	Dredging	Old Pass Channel: 26,700 cu yd.	1971 Ann. Rep.
8-31 Jan 1971	Dredging	East Pass Channel: 81,000 cu yd; Old Pass Channel: 58,000 cu yd; total cost: $325,000.	Disposition forms (DF), 23 Oct 1981, Mobile Archives
11 Jan - 15 Mar 1972	Dredging	Deposition basin: 287,000 cu yd; East Pass Channel: 76,000 cu yd; Old Pass Channel: 57,400 cu yd; total cost $216,000.	DF, 23 Oct 1981, Mobile Archives
4-14 Feb 1973	Dredging	Old Pass Channel: 42,500 cu yd.	DF, 7 Nov 1973, Mobile Archives
14-21 Mar 1973	Dredging	Old Pass Channel: 38,400 cu yd.	DF, 7 Nov 1973, Mobile Archives

(Continued)

(Sheet 6 of 10)

Table A1 (Continued)			
Date	**Event**	**Description**	**Reference**
15 Oct-7 Nov 1973	Dredging	Old Pass Channel: 23,400 cu yd.	DF, 7 Nov 1973, Mobile Archives
6 Nov 1973	Meeting	Colonel Connell, Mobile Dist. Ops Division, and Real Estate Division discussed dedicating a portion of Norriego Point as a Public Park.	Trip rep., 7 Dec 1973, Mobile Archives
7 Nov 1973	Disposition Form	Alton Colvin, Panama City District Engineer, stated that erosion of Norriego Point caused by waves coming through weir. Resulted in rapid shoaling of Destin harbor channel. When seas not running through weir, very little erosion along Norriego Point occurs. Recommend closing weir.	Mobile Dist. Archives
1-21 Dec 1973	Dredging	Old Pass Channel: 9,800 cu yd; total dredging cost 1973: $104,000.	DF, 23 Oct 1981, Mobile Archives
7 Dec 1973	Trip report	Mr. A. F. Pruett reported strong southerly wind and heavy seas entering the Pass between the jetties and over the weir - causing rapid erosion of Norriego Point. Reported general consensus that the East Pass project as constructed also results in propagation of wave energy through Hwy 98 bridge, causing erosion north of the bridge on east side.	Mobile Archives
15 Jan 1974	Trip report	Mr. Robert Jachowski, CERC, visited site on 13 Dec 1973. He believed that the weir jetty system was performing the task for which it was designed. Weir should not be closed at this time. Erosion of Norriego Point should be treated as a separate problem.	Mobile Archives
1 Jan-4 Feb 1974	Dredging	East Pass Channel: 21,000 cu yd; Old Pass Channel: 84,000 cu yd; total cost: $165,000.	DF, 23 Oct 1981, Mobile Archives
Summer 1974	Sand bypassing	Mr. Clark McNair, WES, tested an eductor sand bypassing system at N end of Norriego Point. Reported tremendous amount of sediment moving north, eroded from Point. Pumping system unable to cope with rapid shoaling.	Pers. comm. with Clark McNair, 20 Jul 1990
1-17 Jan 1975	Dredging	East Pass Channel: 120,000 cu yd.	DF, 23 Oct 1981, Mobile Archives
23-30 Sep 1975	Dredging	East Pass Channel: 14,600 cu yd; Old Pass Channel: 17,800 cu yd; total 1975 dredging costs: $85,000	DF, 23 Oct 1981, Mobile Archives
13 Feb 1976	Trip report	Mr. Adrian J. Combe III reported that function of rubble-mound weir good as deposition basin almost filled to mean low water.	CERC Archives
14 Apr-8 May 1976	Dredging	East Pass Channel: 94,000 cu yd; Old Pass Channel: 62,300 cu yd; total cost: $214,000.	DF, 23 Oct 1981, Mobile Archives

(Continued)

(Sheet 7 of 10)

Table A1 (Continued)

Date	Event	Description	Reference
Apr 1977	Report	Design Report proposed six groins along Norriego Point to prevent erosion. Never implemented.	Mobile Archives
28 Apr - 10 May 1977	Dredging	East Pass Channel: 44,000 cu yd; Old Pass Channel: 15,000 cu yd.	DF, 23 Oct 1977 Mobile Archives
1977	Rehabilitation	Repair of jetties completed: $270,000; 300-ft-long groin placed at landward end of, and perpendicular to, the east jetty.	Sargent 1988, p 97
30 May-11 Jun 1978	Dredging	East Pass Channel: 72,700 cu yd; total cost: $409,000	DF, 23 Oct 1981, Mobile Archives
1979	Dredging Management	No more use of US government dredges after 1979. Result: dredging only to project depth and increased frequency needed.	Mobile 1982
16 Apr 1980	Trip Report	Dr. Todd L. Walton, Jr., CERC, reported that littoral transport appeared to be to west predominantly. Recommend closing weir section to prevent waves from shoaling Old Pass Lagoon Channel.	CERC archives.
6 Mar-9 May 1980	Dredging	Old Pass Channel: 22,600 cu yd.	DF, 23 Oct 1981, Mobile Archives
14 Aug-26 Sep 1980	Dredging	Old Pass Channel: 2,100 cu yd; East Pass Channel: 67,000 cu yd	DF, 23 Oct 1981, Mobile Archives
18 Nov 1980	Memo For Record	J. Richard Weggel, CERC, reported that storm waves entering the inlet across the weir have occasionally overwashed Norriego Point. Mobile District repaired breach. Deposition basin adjacent to west jetty has been allowed to fill since it helps attenuate waves that cross weir.	Mobile Archives
7 Jan 1981	Dredging	Old Pass Channel: 250 cu yd.	DF, 23 Oct 1981, Mobile Archives
23-28 Feb 1981	Dredging	Old Pass Channel: 20,900 cu yd	DF, 23 Oct 1981, Mobile Archives
1 May 1981	Memorandum	Mr. Kerr, Mobile District, reviewed recommendation that groins be used to protect Norriego Point.	Mobile Archives
11 Jul-3 Aug 1981	Dredging	East Pass Channel: 44,200 cu yd; total 1981 dredging costs: $363,000	DF, 23 Oct 1981, Mobile Archives

(Continued)

(Sheet 8 of 10)

Table A1 (Continued)

Date	Event	Description	Reference
25 Sep 1981	Disposition Form	Mr. Benton W. Odom, Mobile District, requested evaluation of additional real estate needed in case a new weir were to be placed in the east jetty. Real Estate Division indicated that some of the required land already developed with condominiums. Extensive litigation underway between property owners and State of Florida.	Mobile Archives
Sep 1981	Boat survey	Total fleet of 254 boats permanently docked in Destin and vicinity.	Mobile 1982 report
1982	Report	"Reconnaissance Report East Pass Channel, Destin, Florida," recommended closing weir and proposed 300-ft groin at N tip of Norriego Point (never built).	Mobile Archives
1982	Dredging	Old Pass Channel: 45,700 cu yd; East Pass Channel: 30,500 cu yd; cost: $340,000.	Mr. P. Bradley Mobile, 1990 and 1982 Ann. Rep.
1983	Dredging	East Pass Channel and Old Pass Channel: 59,900 cu yd.	Mr. P. Bradley Mobile, 1990
16 Jun 1983	Trip	Recommendation to initiate monitoring study to document effects of proposed weir closure.	Mobile Archives
29 Jun 1983	Letter	Mr. C. G. Goad and Headquarters, US Army Corps of Engineers, concur that weir to be closed, but Mobile should verify that full project dimensions at East Pass are justified since it might be more economic use of resources to provide a channel of lesser dimensions. Recommend that maintenance dredging take advantage of natural channel.	Mobile Archives
1984	Dredging	East Pass Channel: 141,400 cu yd; Old Pass Channel: 37,900 cu yd	Mr. P. Bradley, Mobile, 1990
Jan 1986	Construction	Weir in west jetty closed by placement of rubble-mound trunk section identical to rest of west jetty.	Memo for Record 13 Mar 1986, CERC
13 Mar 1986	Memo for Record	Mr. J. Michael Hemsley, CERC, noted that 50-ft scour hole developing and main channel migrated somewhat to west.	CERC Archives.
1986	Dredging	East Pass Channel: 150,400 cu yd; Old Pass Channel: 32,000 cu yd.	Mr. P. Bradley, Mobile, 1990
1987	Dredging	East Pass Channel: 126,000 cu yd.	Mr. P. Bradley, Mobile, 1990
23 Feb 1988	Letter	Mr. J. E. Dormum, Jr., City of Destin manager, said Destin contemplating structural improvements to Norriego Point (groins?).	Mobile Archives

(Continued)

(Sheet 9 of 10)

Table A1 (Concluded)			
Date	**Event**	**Description**	**Reference**
29 Feb 1988	Memorandum	Mr. George H. Atkins, Mobile, said that Destin had been advised to delay structural improvements to Norriego Point until study was complete.	Mobile Archives
Apr-May 1988	Dredging	East Pass Channel: 210,800 cu yd; Old Pass Channel: 21,300 cu yd.	Mr. P. Bradley, Mobile, 1990
May 1988	Repair	Scour hole near end of spur jetty filled with sand, capped with concrete rubble.	Mr. H. Peterson, Panama City Area Office, 1990
Feb 1990	Construction	Pumping station constructed at E end of Old Pass Lagoon at site of former gulf entrance. Purpose: seawater circulation to flush stagnant water. Project not completed.	A. Morang, CERC, site visit
Feb 1990	Jetty	About 100 ft of spur jetty (at landward end of E jetty) has been destroyed. Scour hole at tip spreading and getting deeper.	A. Morang, CERC, site visit
8-22 Jun 1990	Repair	Stone riprap placed near N end of Norriego Point to retard erosion	Mr. H. Peterson, Panama City Area Office, 1990
Mar 1991	Dredging	East Pass Channel: 131,900 cu yd; Old Pass Channel: 11,500 cu yd;	Mr. R. Beacham, Mobile, 1991
Apr 1991	Jetty	About 100 ft of spur jetty destroyed. Total spur only about 100 ft long now.	A. Morang, CERC, site visit
May 1991	Repair	To reduce shoaling in Old Pass Channel, two geotextile fabric groins installed at tip of Norriego Point. Jet pump to bypass sand demonstrated for 2 days.	Mr. James Clausner, CERC, site visit

(Sheet 10 of 10)

Appendix B
Estimation of Error of Ebb-Tide Shoal Growth Calculations

Hydrographic surveys of East Pass are conducted by the Panama City Area Office, US Army Engineer District, Mobile (SAM). SAM's surveyors have estimated the vertical accuracy of the surveys performed since the 1960's to be ± 0.3 ft. This value was determined in light of frequent calibration checks of the echosounders and the use of tide gages in the survey area to measure the local tide effect. Electronic microwave navigation is used for all hydrographic surveys.

The error in the volumetric difference between surveys was estimated by determining how much the average depth in each polygon changed from one survey to another and then calculating an average depth change over all 18 polygons. For example, when comparing the 1986 and the 1990 surveys, ΔZ values for the 18 polygons are:

3, 1, 2, 2, 1, 4, 2, 5, 1, 3, 2, 9, 9, 2, 4, 3, 2, and 0 ft.

Therefore, ΔZ_{ave} is $55/18 = 3.1$ ft . The maximum likely error is:

$$0.6 \text{ ft}/3.1 \text{ ft} = 0.20 = 20 \text{ percent}$$

Using the above procedure, error estimates for the six survey comparisons are listed in Table B1.

Table B1
Error Estimates of Ebb-Tide Shoal Depth Differences

Survey	Δ_{ave}, ft	Max Likely Error, %
1990 - 1986	3.1	20
1986 - 1983	4.1	15
1983 - 1974	3.9	15
1974 - 1970	2.3	26
1970 - 1969	1.8	33
1969 - 1967	2.2	27

The maximum depth change (ΔZ_{max}) in any polygon was 9 ft, while the minimum change (ΔZ_{min}) was 0 ft. For the comparisons listed in Table B1, 96 polygons had ΔZ less than or equal to 5 ft.

Actual error may be less than the estimates listed above. ΔZ was averaged over the $1{,}000 \times 1{,}000$ ft polygons. Although a particular polygon might have averaged ΔZ of only 1 or 2 ft, water depths from spot to spot within the polygon often varied considerably more. Therefore, if smaller polygons had been used for the volumetric calculations, ΔZ would typically have been greater and maximum likely error accordingly less.

It has been assumed that errors in positioning (ΔX and ΔY) were random and had an insignificant effect on the volumes compared with possible systematic errors in water depth measurements and data reduction.

Waterways Experiment Station Cataloging-in-Publication Data

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